

The interference rejection test results in this report are presented as signal levels at the threshold of visibility (TOV) of picture degradation—*i.e.*, the point at which picture degradation (in the form of pixilation, image freezes, or dropouts) becomes visible. Increases in interfering signal level above this point result in further degradation—and ultimately complete loss—of the TV picture.

Though the “hardness” of the thresholds was not one of the measurement parameters for this study, a strong “cliff effect” was observed during the tests. For example, in most cases, increasing interference level about 1 dB above TOV caused complete loss of picture. In some cases picture loss didn’t occur until the undesired signal level rose as much as 3 dB and in one case, 5 dB (though picture errors occurred continuously in that case after only a 1.5 dB increase). In a few cases picture loss occurred concurrently with appearance of errors or with only an additional 0.1 dB increase in interference—an extremely abrupt cliff! By contrast, interference to analog TV occurs much more gradually. An 8-dB increase in signal level of an interferer from the TOV level for analog TV may cause the interference effect to grow to the “slightly-annoying” level, from the TV viewer’s point of view.* A total increase of 20 to 30 dB may be required to make the analog picture unusable.†

INTERFERENCE FROM A SINGLE UNDESIRE SIGNAL

The interference tests with a desired signal on channel 30 were performed using an 8-VSB undesired signal for first-adjacent channels (N-1 and N+1) and a white Gaussian noise signal bandlimited to match the 3-dB width of an 8-VSB signal for all other channels.

Measurements of interference rejection performance are specified in terms of desired signal power D and undesired (*i.e.*, interfering) signal power U at the RF input of the DTV receiver. We have chosen to present the interference rejection performance measurements in two ways: as D/U ratios and as threshold values for the undesired signal level U . Each has its own application. D/U ratios might be preferable for all analytical work if they were constant with desired signal power; however, nonlinearity of interference mechanisms and the effects of receiver noise at low desired signal levels cause D/U ratios to be variable. Nonetheless, D/U ratios can be convenient to use in applications like DTV-into-DTV interference assessment because estimation of D/U ratios may be easier and more accurate than estimation of absolute levels where long-distance propagation is involved—especially if the broadcast stations are co-sited. Use of absolute signal level thresholds may be more appropriate for assessing shorter distance interference from low-power devices because the effects of TV antenna height and placement on the undesired signal are likely to be very different from their effects on the desired signal.

No receiver appeared to fully achieve the ATSC recommended guidelines for interference rejection performance. After taking into account differences between the Gaussian-noise interferer used for most of the tests and the 8-VSB interferer specified by the ATSC, the best-performing receiver appears to fail the guidelines at only one channel offset, and there by only 1 dB. A second receiver failed to meet the voluntary guidelines by 1 to 2 dB at two channel offsets. The remaining five receivers failed to meet the guidelines at two to 16 channel offsets; the worst failure for each of those receivers ranged from 8 to 24 dB.

The single-channel rejection performance measurements performed for this report are best summarized by Figures 15-1 through 15-6. The first graph presents the rejection performance in terms of D/U ratios and

* Tests of interference rejection thresholds for DTV into analog NTSC TV for 8 taboo channels show that D/U ratios differed by an average of 8.1 dB between TOV and CCIR Grade 3 (“Slightly Annoying”) at a weak signal level. These results were obtained by averaging data from table in Bretl and Sgrignoli, 1996, section 3.8.3.

† Tests of lower-adjacent interference rejection thresholds for DTV into analog NTSC TV showed a difference of 20.2 dB between D/U ratio at TOV and D/U ratio at the point of unusability at a weak signal level. Similar tests for co-channel interference showed a difference of 32 dB between TOV and the point of unusability (Bretl and Sgrignoli, 1996, sections 3.8.1 and 3.8.2.1).

the second in terms of the undesired signal power at TOV. The first pair of graphs presents the *median* rejection performance across the eight DTV receivers at each of the tested channel offsets (from N-16 to N+16—omitting the co-channel case). The second pair presents the *second-worst* performance across the *eight receivers*. The third pair presents the *worst* performance.

Each graph shows the interference thresholds at five desired signal levels: -28 dBm, -53 dBm, -68 dBm, $D_{\text{MIN}} + 3$ dB, and $D_{\text{MIN}} + 1$ dB, where D_{MIN} is the desired signal level corresponding to the TOV for the receiver in the absence of interference. For measurements at $D_{\text{MIN}} + 3$ dB, each TV was tested by first measuring its minimum signal threshold D_{MIN} , then setting the desired signal power 3 dB higher than that threshold for the interference rejection tests. Thus the desired signal level was different for each DTV receiver. The results at $D_{\text{MIN}} + 1$ dB were extrapolated from the measured values at $D_{\text{MIN}} + 3$ dB by means of a model developed in Chapters 8 and 12.

Each graph shows measurement limitations imposed by the test setup—in the form of solid black lines and a shaded region. The D/U plots (Figures 15-1, 15-3, and 15-5) show four measurement limit curves that correspond, from top to bottom, to limits at $D = -28$ dBm, -53 dBm, -68 dBm, and $D_{\text{MIN}} + 3$ dB, respectively. In the case of data extrapolated to $D_{\text{MIN}} + 1$ dB, data points are shown only if the measurements on which they were based were not subject to measurement limits. The undesired signal threshold plots (even-numbered Figures 15-2, 15-4, and 15-6) show only one measurement limit curve—the curve associated with the maximum undesired signal power that the test setup could inject into the receiver; the N-1 and N+1 offsets for $D = -68$ dBm and all of the offsets for $D = D_{\text{MIN}} + 3$ dB are subject to an additional limitation—shown only in the D/U plots—that is caused by leakage of the undesired signal into the desired channel.

We make the following observations regarding the results.

- In terms of absolute signal levels that can cause interference, the TVs are at their most vulnerable when operating at low desired signal levels.
- At low desired signal levels the TV receivers are *as* susceptible to interference from the second-adjacent channels (N-2 and N+2) as from first-adjacent channels (N-1 and N+1) in terms of median performance of the receivers. In terms of worst and second-worst performance, the receivers are *more* susceptible to interference from second-adjacent channels than from first-adjacent channels. (This contradicts the assumptions of OET-69 and the receiver performance guidelines of ATSC Document A/74.)
- The receivers tend to be more susceptible to interference from N+2, N+1, N-1, N-2, N-3, N-4, and sometimes N-6 than from the mixer image channel offsets of N+14 and N+15.
- At moderate desired signal levels, the receivers exhibit relatively high susceptibility to interference from channel N+7. This interference threshold is nearly constant in terms of absolute power of the undesired signal necessary to cause interference at different levels of desired signals. At lower desired signal levels, other channel offsets become more vulnerable.

INTERFERENCE FROM IM3-GENERATING PAIRS OF UNDESIRE SIGNALS

Pairs of undesired signals placed on channels N+K and N+2K, where K is a positive or negative integer, create an opportunity for third-order intermodulation (IM3) occurring in the DTV tuner to create spectral products that fall in the desired channel N. We had anticipated paired-signal IM3 effects would be significant only at high signal levels; however, detailed measurements on one DTV receiver (Chapter 11) demonstrated that such effects can constitute a dominant interference susceptibility even at desired signal levels very near the minimum signal threshold for the TV, when such signal pairs exist.

Measurements of interference thresholds were performed with equal-powered undesired signals on $N+K/N+2K$ combinations for eight DTVs on channel 30 and seven of those DTVs on channel 51. Tests were performed for $K = -5$ to 5 when N was 30 and for $K = 1$ to 8 when N was 51. In both cases, desired signal levels were set to -68 dBm and -53 dBm. Not all measured cases produced interference effects that were sufficiently higher than the single-channel interference effects to allow measurement of the IM3 effects. For those that were, a third-order intercept point (IP3) was computed.

The data was carefully examined to identify cases for which median, second-worst, and worst IP3 across the eight receivers could be determined. In cases in which corresponding values (e.g., "second-worst") were obtained from both the channel 30 measurements and the channel 51 measurements, the results were averaged across the two channels; in cases where only one channel yielded a value, that value was used. IP3's computed from that data were used to extend the results, by calculation, to desired power levels of $D_{\text{MIN}} + 3$ dB and $D_{\text{MIN}} + 1$ dB. For simplicity, that calculation assumed that $D_{\text{MIN}} = -84$ dBm for each receiver.

Figure 15-7 shows the *median* D/U ratios across the eight tested receivers for a desired signal level of -68 dBm. The "Single Signal" curve is a duplicate of the corresponding curve from Figure 15-1. Paired signal combinations for which IM3 effects were measurable across a sufficient set of receivers to allow the median IP3 to be computed are shown as pairs of large red dots connected by straight lines. The horizontal pairs represent rejection thresholds for equal-level undesired signals. For example, the connected pair of dots at $N+3$ and $N+6$ indicates that the median D/U ratio for a signal pair at $N+3$ and $N+6$ is -43.7 dB when the desired signal level is -68 dBm. (For equal-powered undesired signals, the "U" in the D/U ratio is $U = U_{N+K} = U_{N+2K}$.)

The right-most signal pair ($N+8/N+16$) was plotted in three ways—as an equal-power signal pair (horizontal line) and as two sets of unequal pairs. Unequal pairs were created by raising and lowering the $N+8$ point by 10 dB, which results in a ± 20 dB change in the threshold for $N+16$. The example illustrates behavior that would be exhibited by any of the signal pairs for unequal signals with such a signal level deviation. That is, if U_{N+K} were to change by X dB from the equal-level threshold value, the U_{N+2K} threshold would change by $-2X$ dB. Thus, the presence of a signal stronger than the equal-power threshold on one channel in a pair, makes the other channel susceptible to weaker undesired signals. In the example, increasing the undesired signal power at channel $N+8$ by 10 dB from the equal-power threshold (resulting in a 10 dB *decrease* in D/U at $N+8$) causes the threshold D/U ratio at $N+16$ to increase from its equal power value of -51.4 dB to -31.4 dBm. The result is that the susceptibility of the TV to interference on channel $N+16$ is now greater than its susceptibility to interference on the first adjacent channels ($N-1$ or $N+1$). Charts and tables in Chapter 10 illustrate the range of thresholds that can result.

We note that the behavior of unequal signal pairs as described in the previous paragraph and quantified in the charts and tables of Chapter 10 is valid only over signal level regions for which the receiver's automatic gain control (AGC) does not act to reduce tuner gain prior to the nonlinearity that causes the IM3 effects (usually in the mixer). In some cases (including one identified in Chapter 14), a large increase in U_{N+K} for small K values may cause such AGC gain reductions. When that happens, the model predicts that the sensitivity of the receiver to interference on $N+2K$ will freeze—exhibiting no further increases in interference susceptibility with further increases in U_{N+K} .

Regarding signal pairs that are missing from Figure 15-7 (and from the subsequent plots that will be introduced), we note the following.

- In the case of the first-adjacent pairs ($N-1/N-2$ and $N+1/N+2$) the values are missing because the measurements of paired-signal thresholds for those channel pairs did not exceed single-channel effects on any of the receivers by a sufficient amount to support measurement of IM3 effects. (We note that equal undesired signal powers levels are not necessarily optimal for detecting IP3 effects, so

it is not known whether IM3 estimates could have been obtained from measurements at unequal levels.)

- In the case of channel pairs N-3/N-6, N-2/N-4, N+2/N+4 and N+7/N+14, IM3 effects were *successfully measured for some of the receivers, but the receivers that did not support such measurement created uncertainty in trying to determine worst, second-worst, and median values of the IP3 parameter; consequently, those values are missing from the graphs.*
- No signal pair measurements were performed beyond N-5/N-10 in on the left side of the plots.

It can be seen on the right side of the plot, where measurements are more plentiful, that the paired-signal interference effects gradually decrease with separation from the desired channel.

If one were interested in determining general undesired signal levels at which IM3 can interfere with TV reception, the “Equal Signal Pairs” plots in Figure 15-7 (and in subsequent charts to be described next) could be used to identify a level that could cause interference *if* a similar signal level happens to occur at another channel offset that would place IM3 products in the desired channel. If, on the other hand, one wanted to determine case-specific interference vulnerabilities that take into account *existing* undesired sources (*e.g.*, a nearby DTV broadcast station when the receiver is tuned to a more distant station), one could use the data from Chapter 10 to determine the signal level associated, for example, with a new non-TV service that would cause interference under specific reception conditions. Such analysis using signal levels from existing channel allotments could reveal greater interference susceptibilities than those based on equal signal pairs.

Figure 15-8 presents the same data as Figure 15-7, but shows it as the threshold value of undesired signal power U rather than as a D/U ratio.

The previous two plots corresponded to *median* receiver performance with a desired signal level of -68 dBm. The subsequent two pairs of charts show similar data for the second-worst and worst performing receivers. That six-chart sequence is followed by six charts corresponding to a desired signal level of $D_{\text{MIN}} + 3$ dB and six more charts corresponding to a desired signal of $D_{\text{MIN}} + 1$ dB.

The plots show that IM3 between paired signals can be the dominant source of interference at many channel offsets, when undesired signals exist at IM3-generating spacings ($N+K/N+2K$). IM3 interference effects from paired signals on the first-adjacent channel pair ($N+1/N+2$ or $N-1/N-2$) appear to be less important than the single-channel interference effects for first adjacent channels; the same is sometimes, but not always, true for the second adjacent pair ($N+2/N+4$ or $N-2/N-4$). At other channel spacings the paired signal IM3 effects dominate when the desired signal level is -68 dBm.

As desired signal level drops, IM3 effects diminish more rapidly than first- and second-adjacent single-channel interference effects. This can be seen by comparing, for example, Figures 15-7 and 15-19. Nonetheless, paired-signal IM3 appears to be the dominant interference vulnerability for channel offsets from about N+4 to N+16 (with the exception of the mixer image at N+14 and N+15) and from about N-5 to N-10, even at desired signal levels near D_{MIN} and even if the paired signals are assumed to be equal in level. No paired signal measurements were performed beyond N+16 and N-10, so it is not known how far out the effect continues; however, the effect is seen to diminish with increasing channel offset from the desired channel.

Paired signals at IM3-generating spacings have the potential to create even greater interference susceptibilities if an existing undesired signal on one of the IM3-generating channels (*e.g.*, a nearby DTV broadcast station when the receiver is tuned to a more distant station) exceeds the measured equal-power-level threshold for paired signals. In such a case, the presence of that signal can greatly increase susceptibility to interference on the other channel of the IM3-generating pair. This situation generally creates the greatest vulnerabilities when the stronger undesired signal is on channel $N+K$ and it exceeds

the equal-power paired-signal threshold; in that case, the receiver susceptibility to interference on the $N+2K$ channel increases by twice the $N+K$ signal excess above the equal power threshold.

The ATSC Receiver Guidelines document (A/74) provides no recommended performance levels for rejection of paired-signal interference.

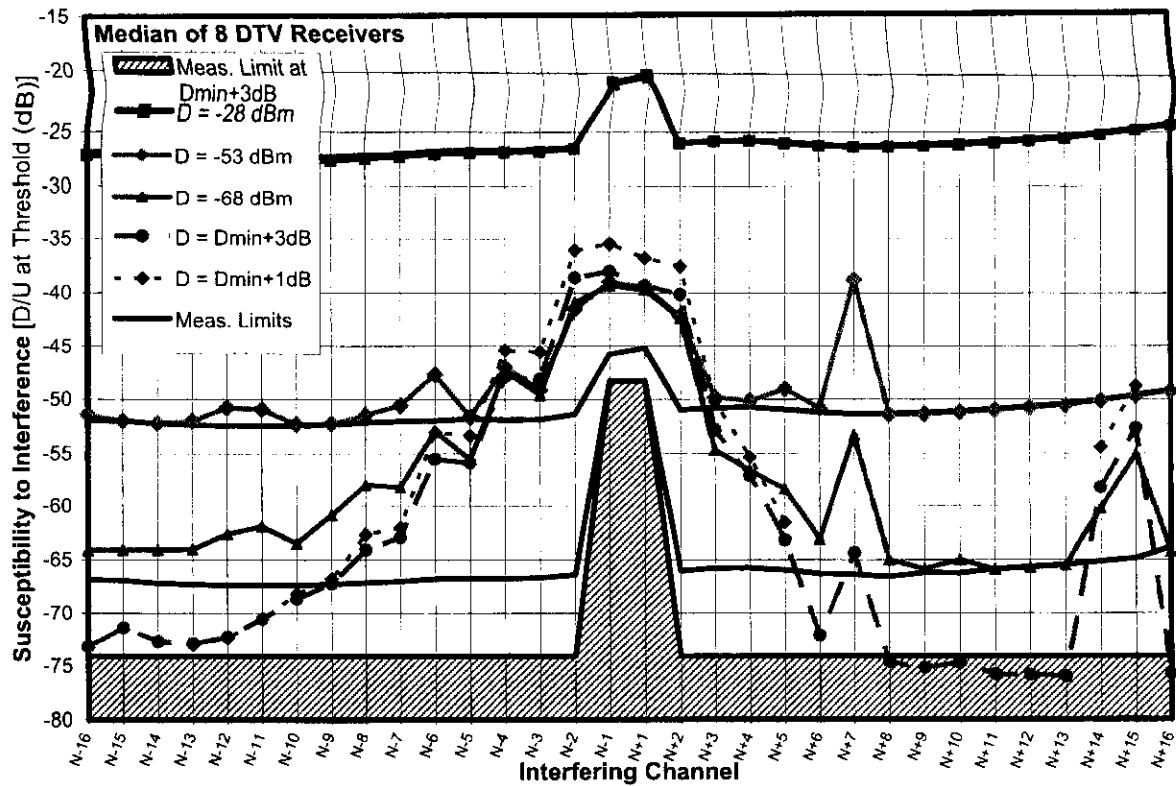


Figure 15-1. Median D/U of 8 Receivers at Five Signal Levels on Channel 30

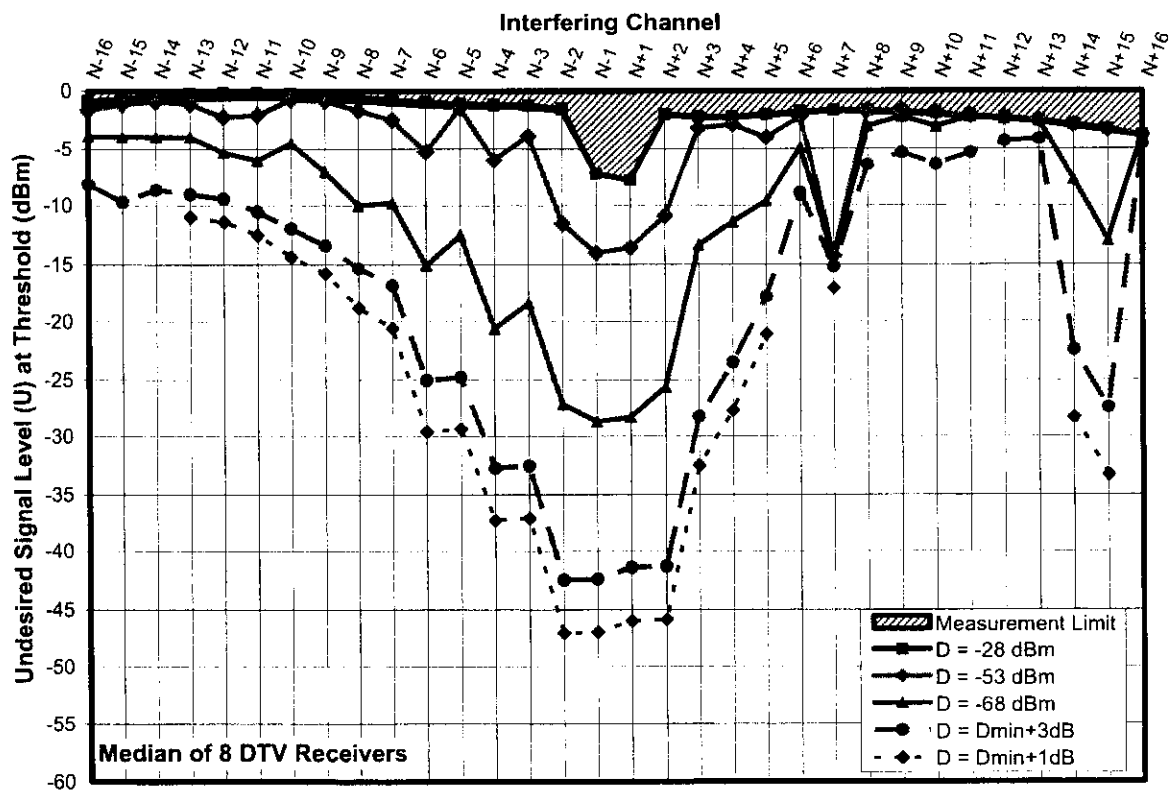


Figure 15-2. Median Threshold U of 8 Receivers at Five Signal Levels on Channel 30

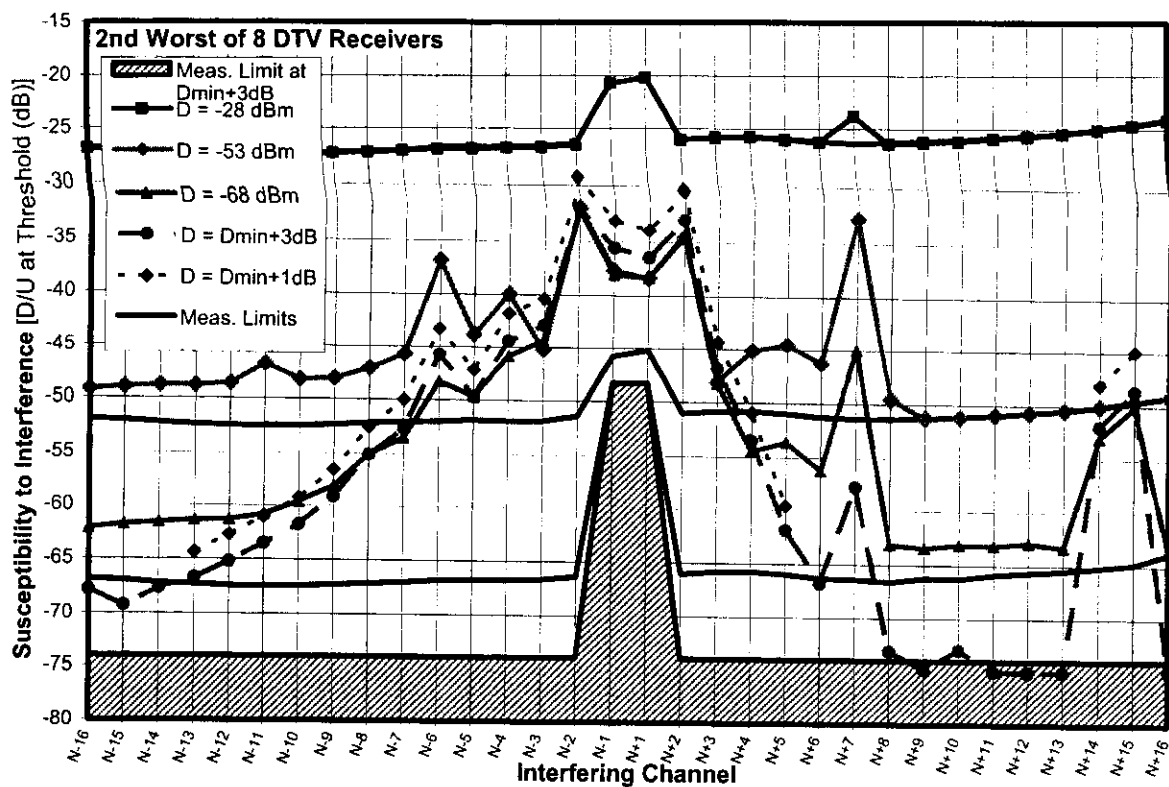


Figure 15-3. 2nd Worst D/U of 8 Receivers at Five Signal Levels on Channel 30

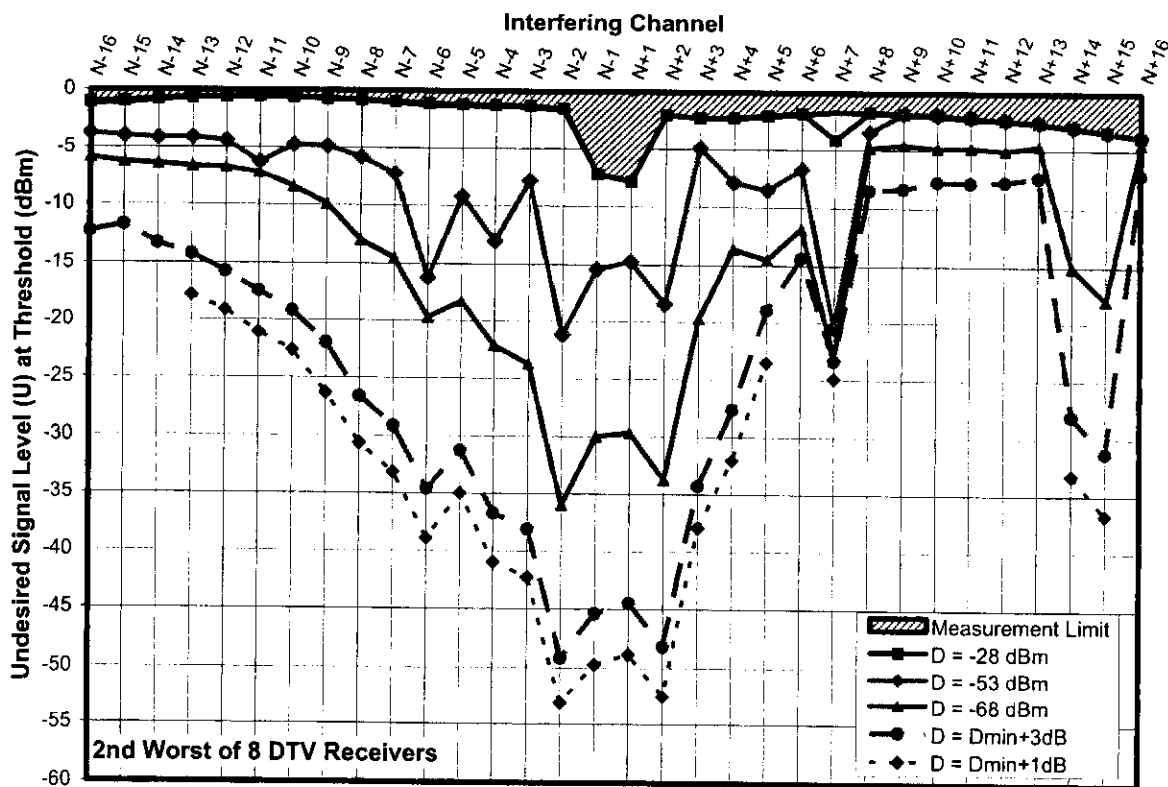


Figure 15-4. 2nd Worst Threshold U of 8 Receivers at Five Signal Levels on Channel 30

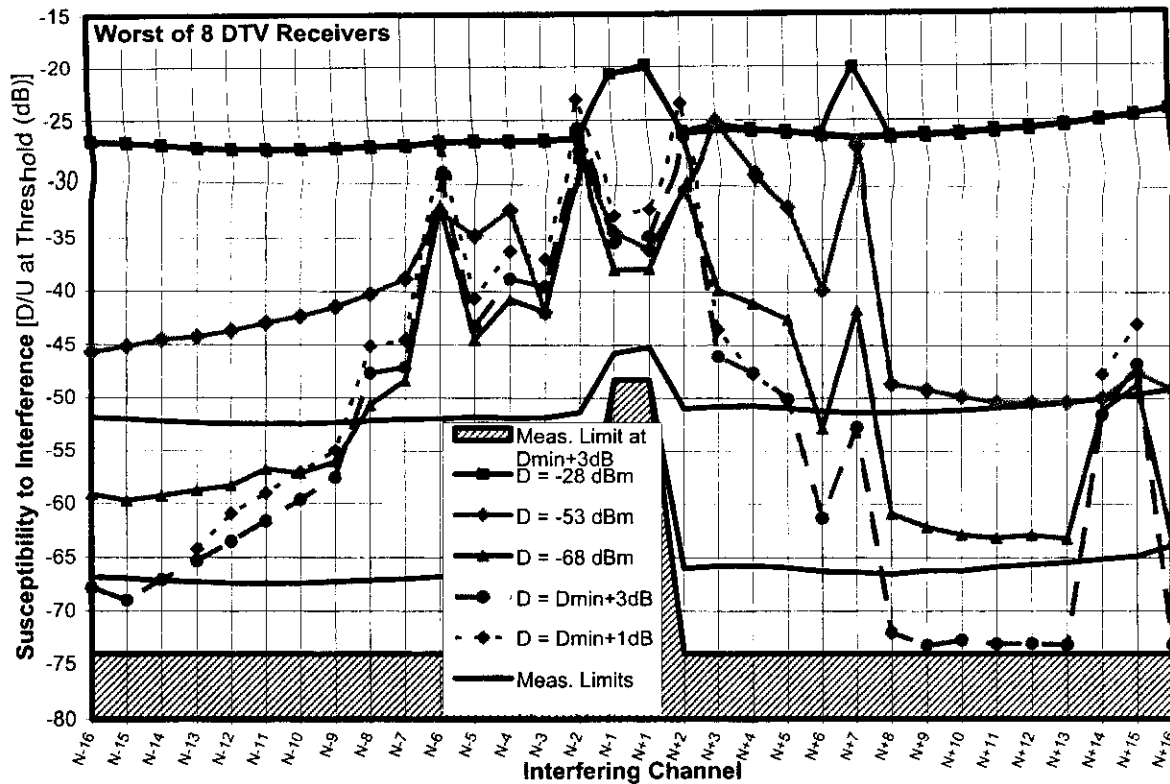


Figure 15-5. Worst D/U of 8 Receivers at Five Signal Levels on Channel 30

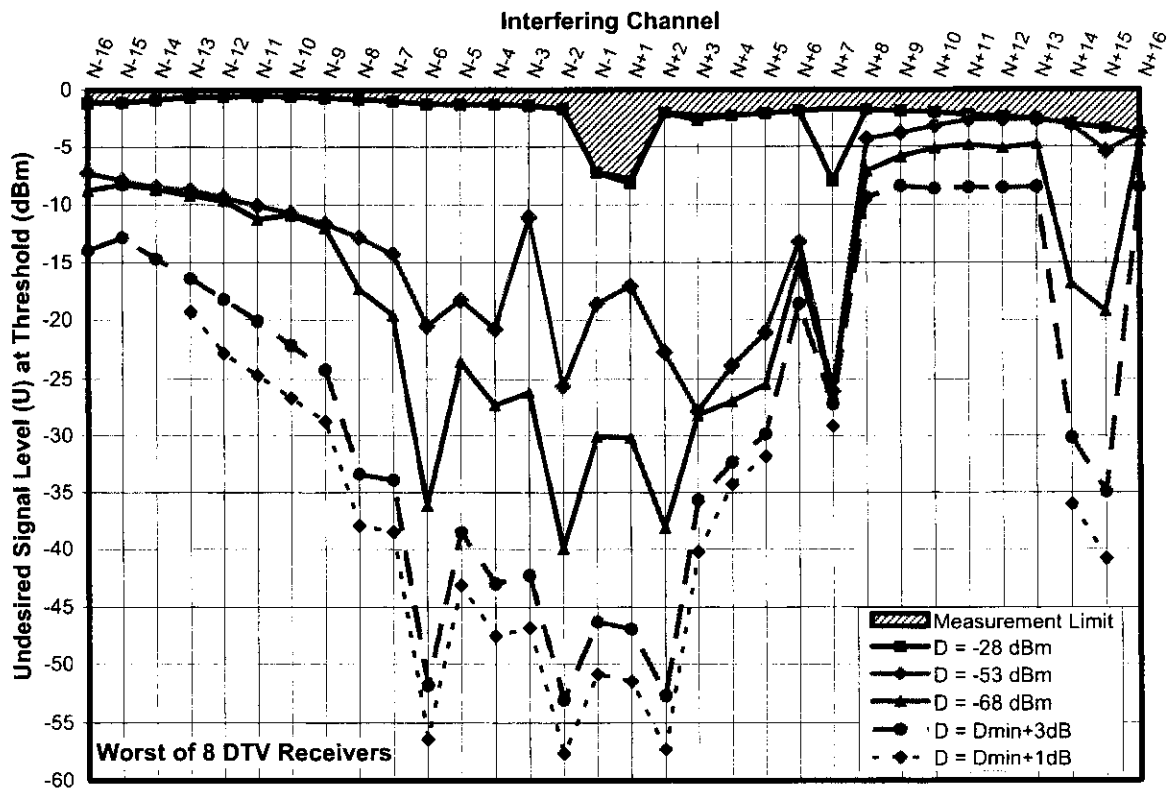


Figure 15-6. Worst Threshold U of 8 Receivers at Five Signal Levels on Channel 30

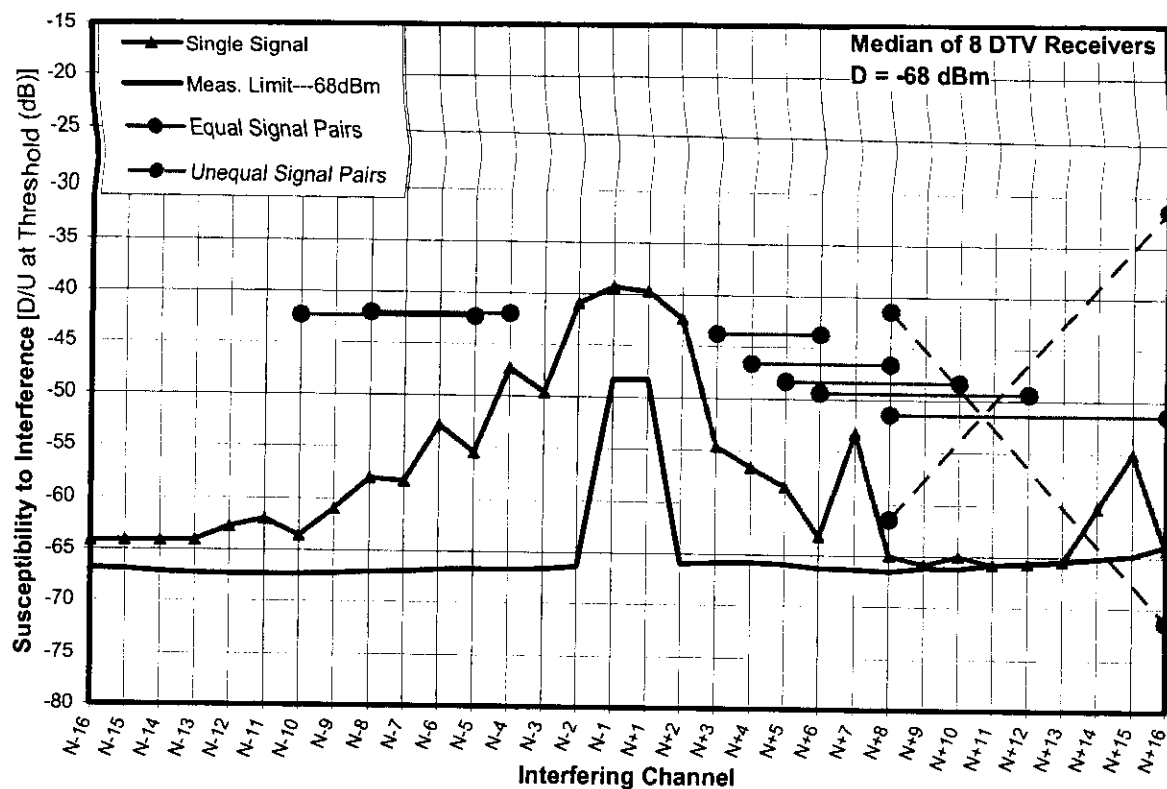


Figure 15-7. Median D/U of 8 Receivers at D = -68 dBm With IM3 Signal Pairs

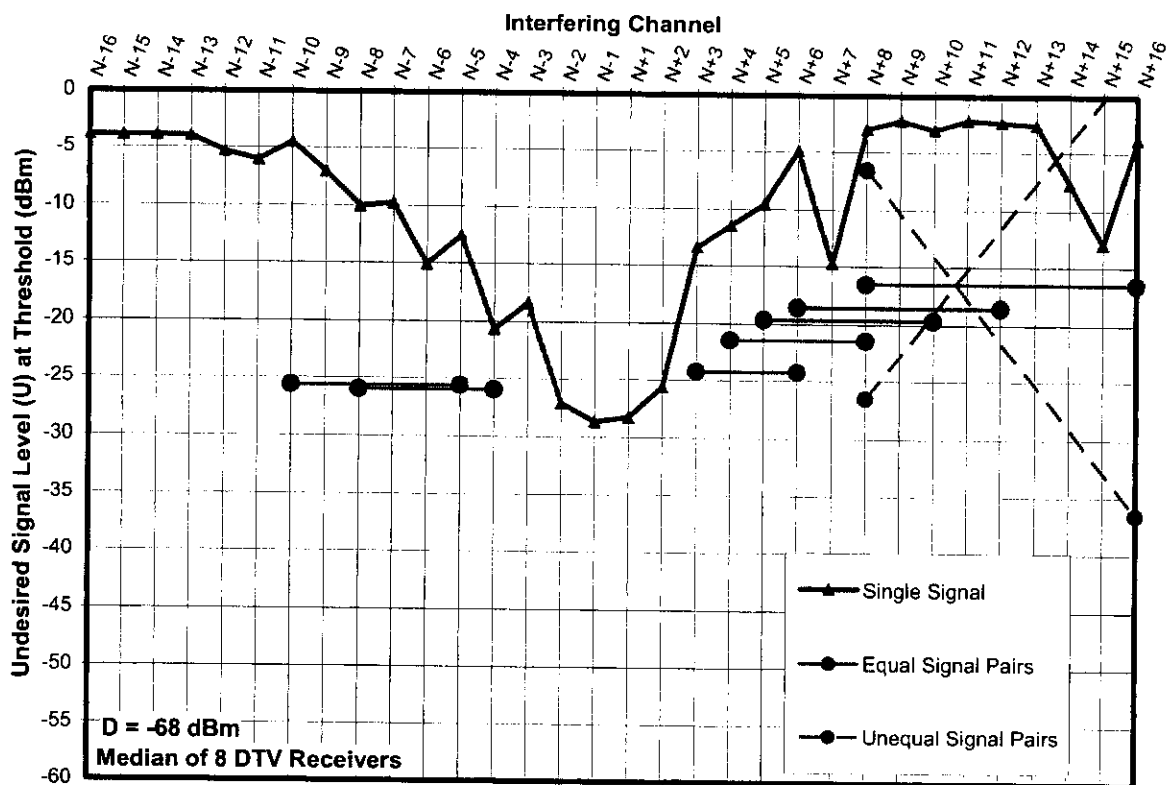


Figure 15-8. Median Threshold U of 8 Receivers at D = -68 dBm With IM3 Signal Pairs

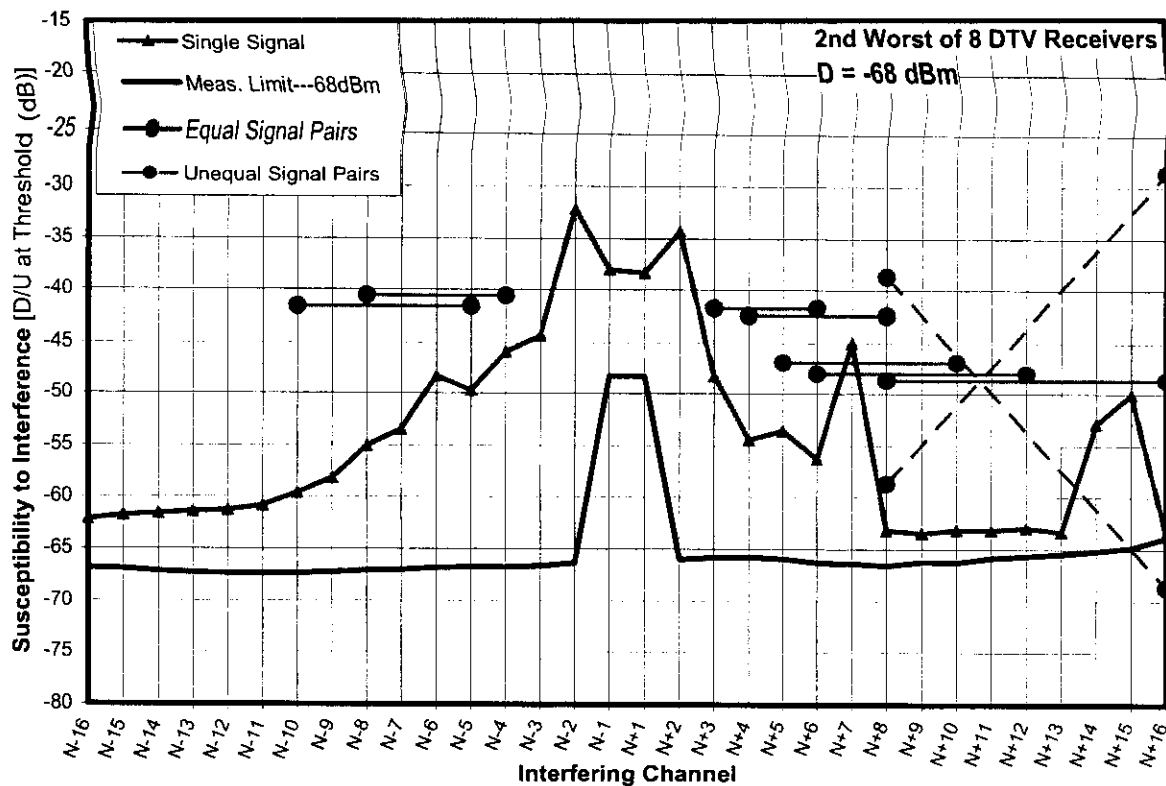


Figure 15-9. 2nd Worst D/U of 8 Receivers at $D = -68$ dBm With IM3 Signal Pairs

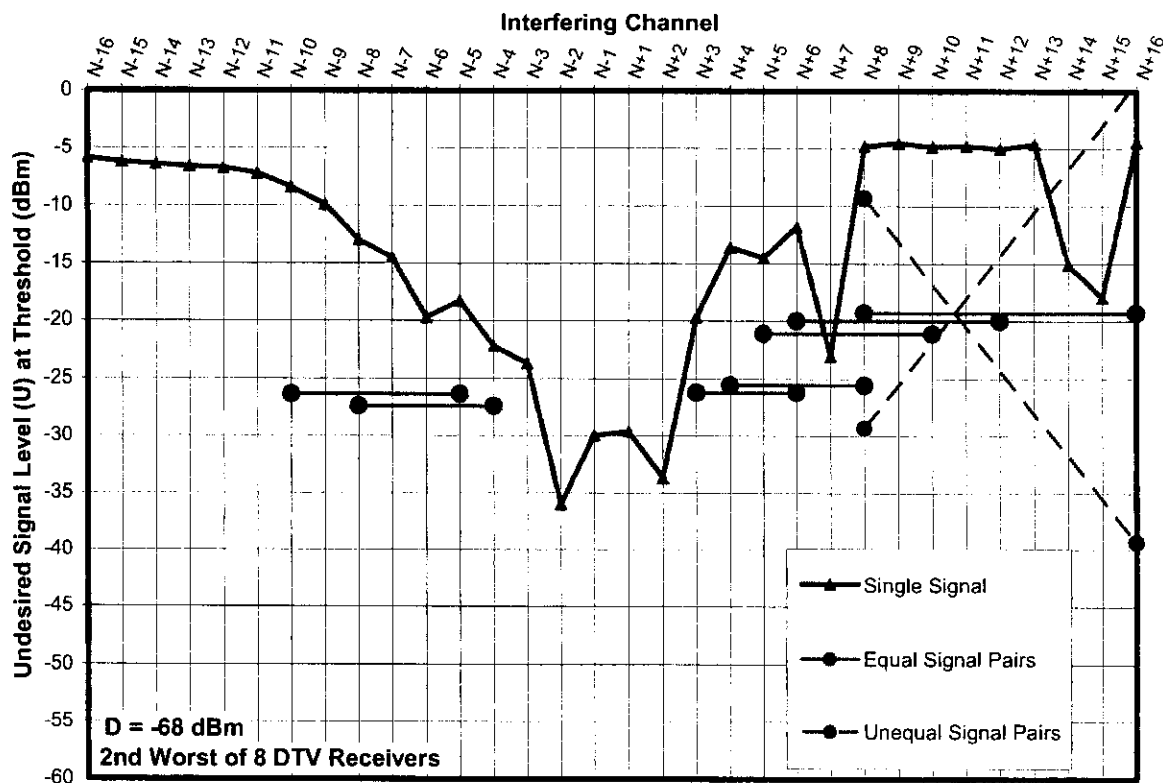


Figure 15-10. 2nd Worst Threshold U of 8 Receivers at $D = -68$ dBm With IM3 Signal Pairs

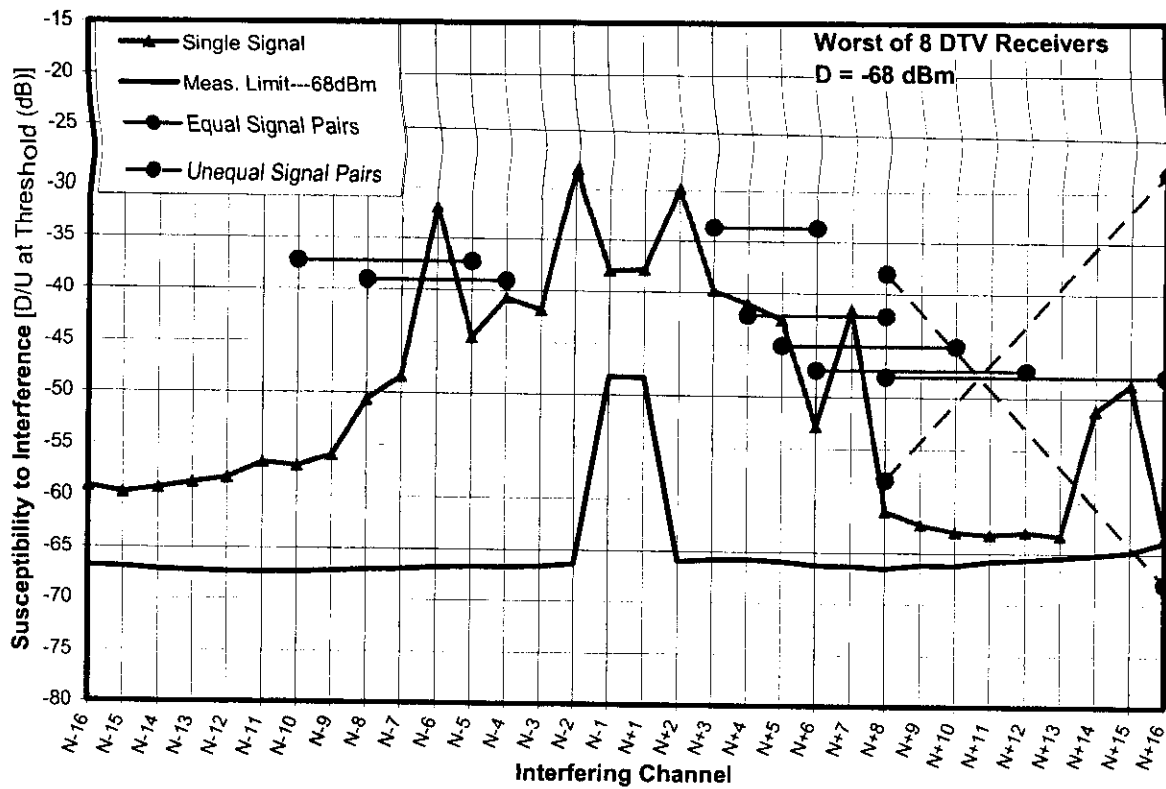


Figure 15-11. Worst D/U of 8 Receivers at $D = -68$ dBm With 1M3 Signal Pairs

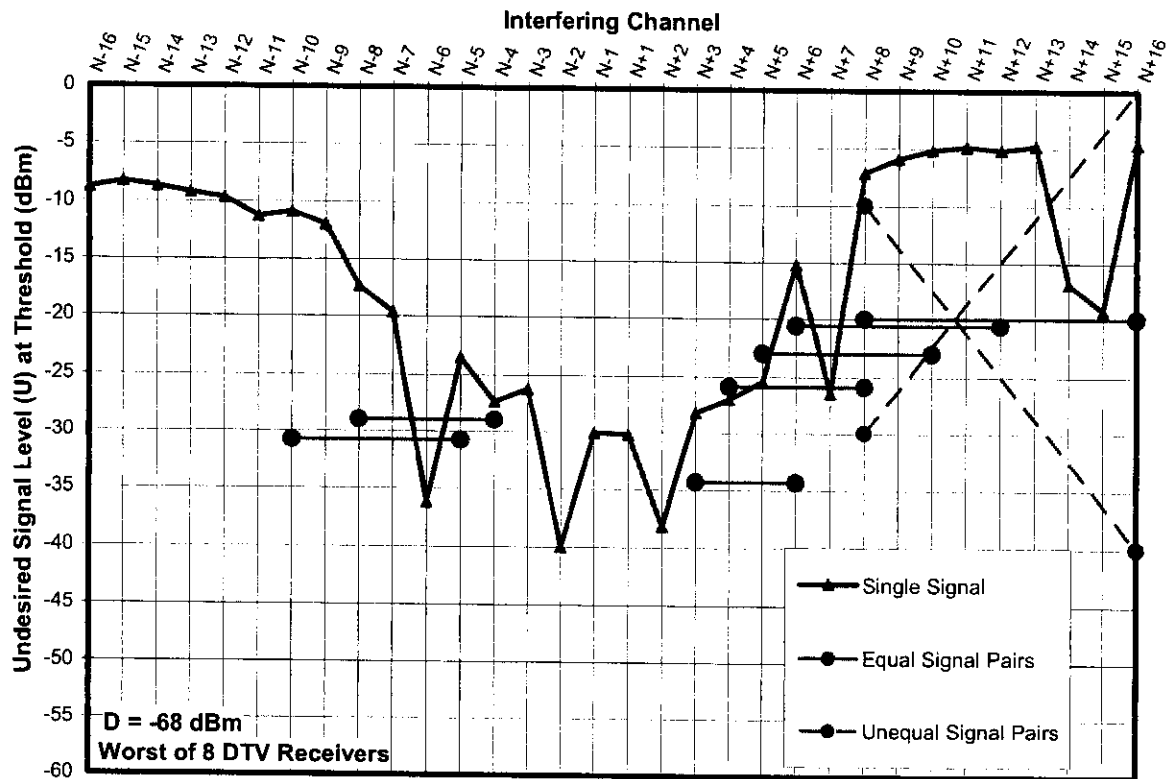


Figure 15-12. Worst Threshold U of 8 Receivers at $D = -68$ dBm With 1M3 Signal Pairs

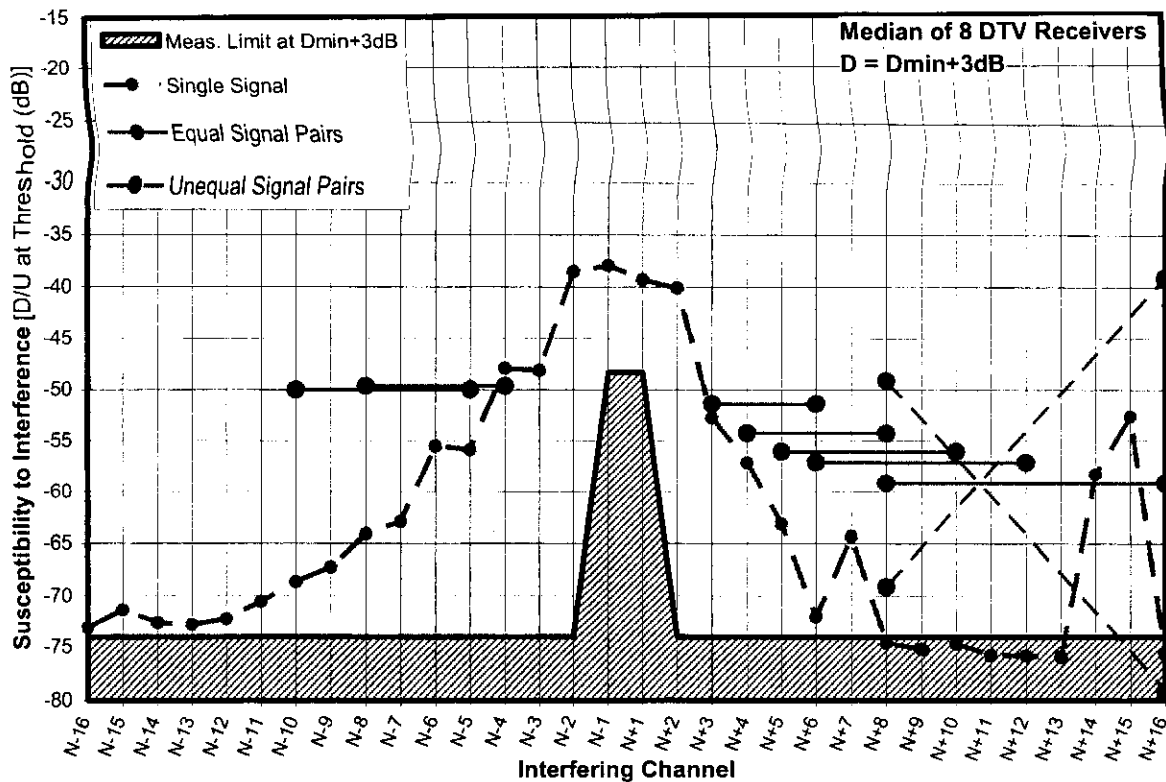


Figure 15-13. Median D/U of 8 Receivers at $D = D_{MIN} + 3\text{dB}$ With IM3 Signal Pairs

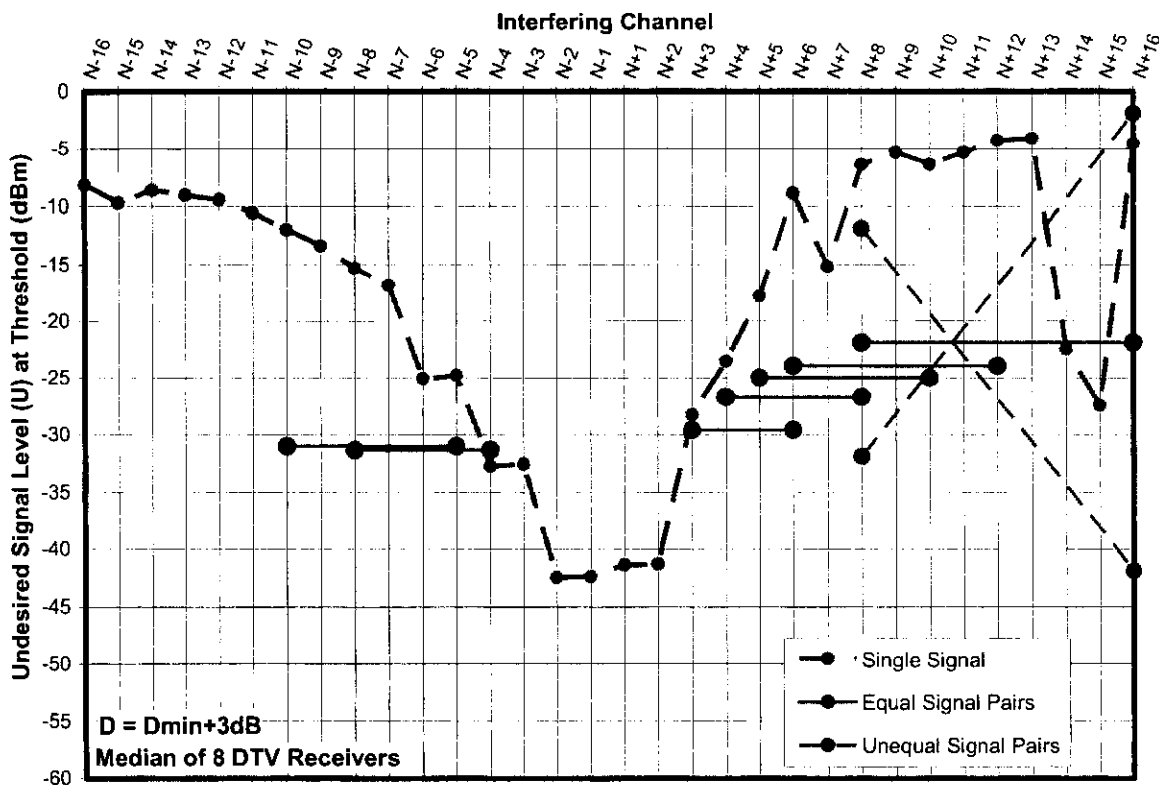


Figure 15-14. Median Threshold U of 8 Receivers at $D = D_{MIN} + 3\text{dB}$ With IM3 Signal Pairs

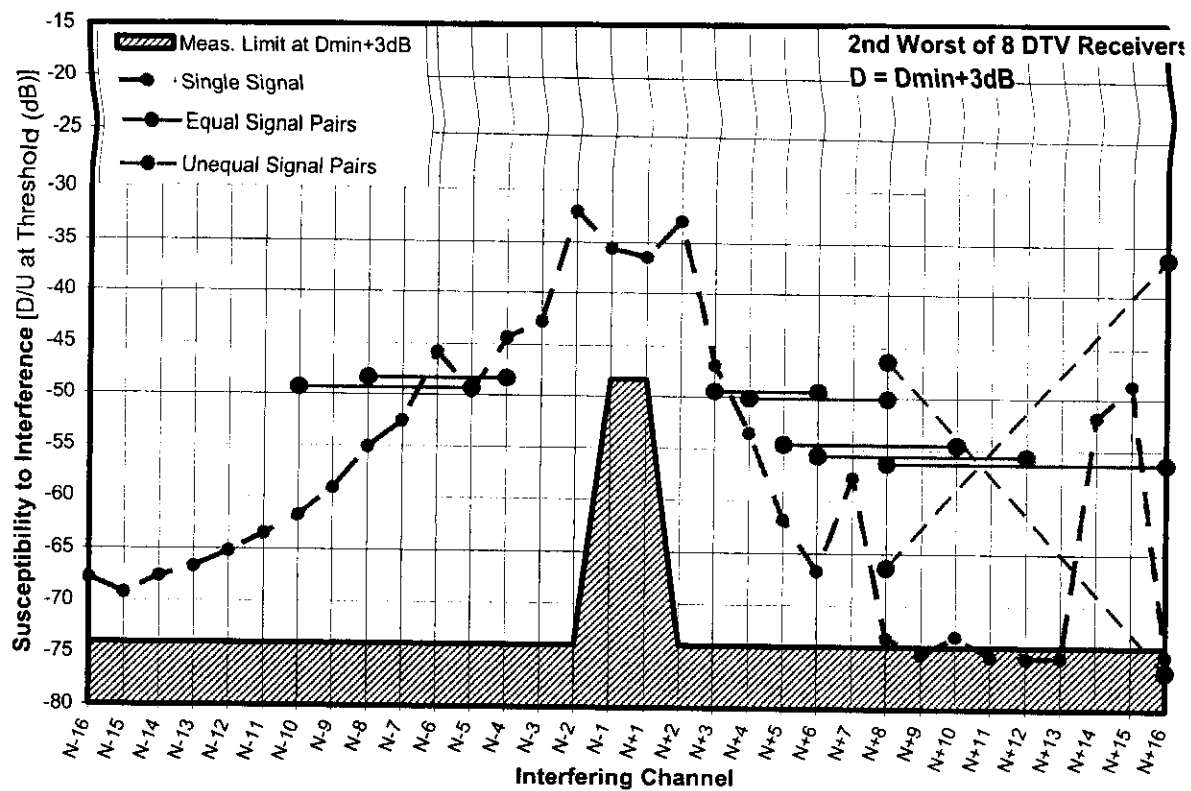


Figure 15-15. 2nd Worst D/U of 8 Receivers at $D = D_{\text{MIN}} + 3\text{dB}$ With IM3 Signal Pairs

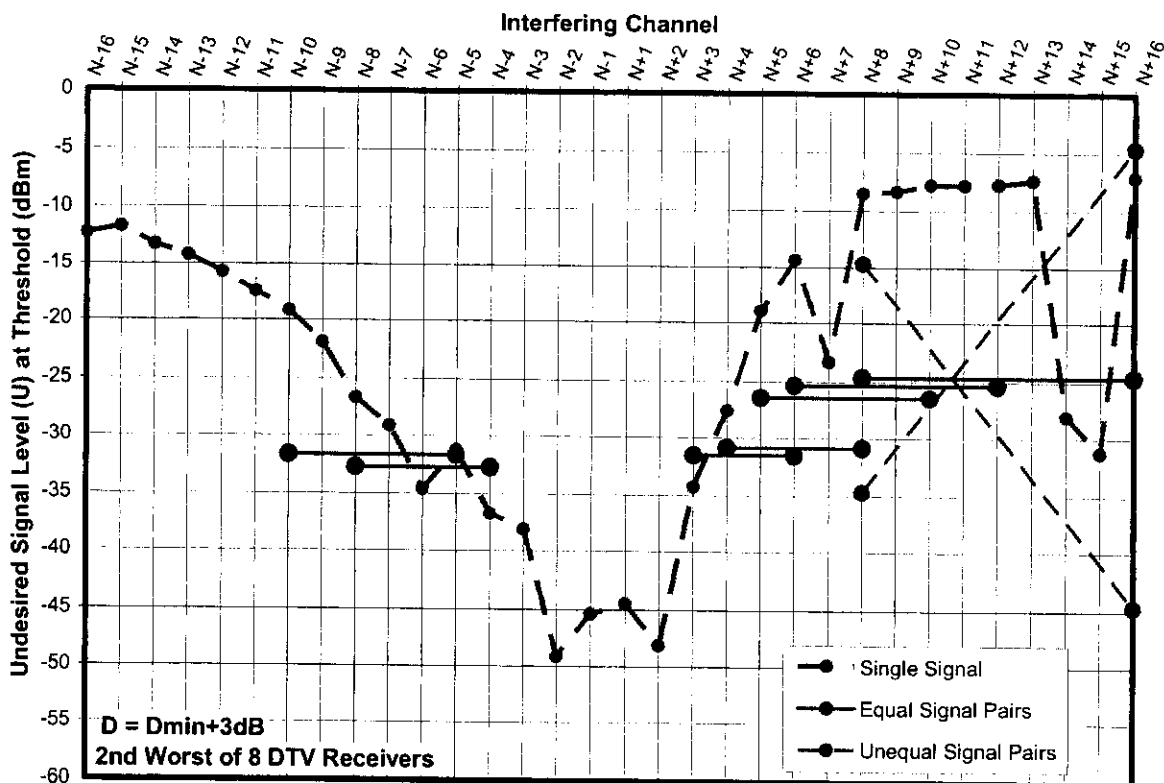


Figure 15-16. 2nd Worst Threshold U of 8 Receivers at $D = D_{\text{MIN}} + 3\text{dB}$ With IM3 Signal Pairs

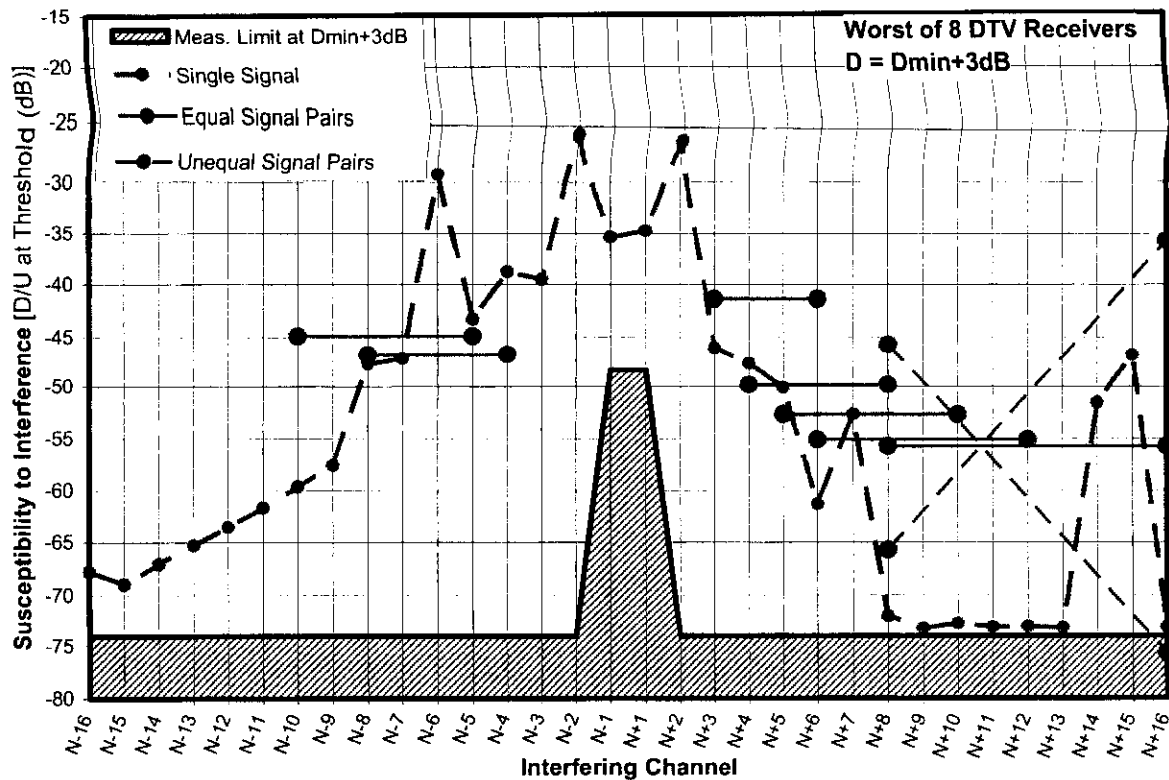


Figure 15-17. Worst D/U of 8 Receivers at $D = D_{MIN} + 3dB$ With IM3 Signal Pairs

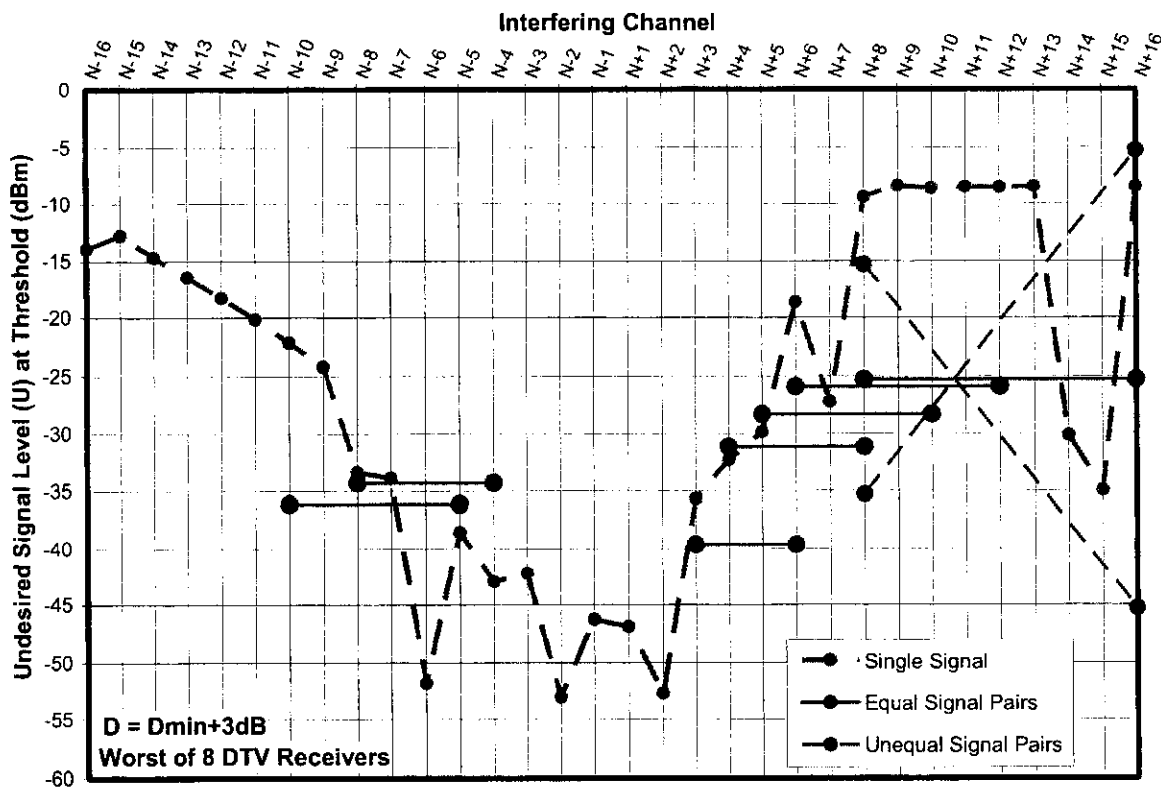


Figure 15-18. Worst Threshold U of 8 Receivers at $D = D_{MIN} + 3dB$ With IM3 Signal Pairs

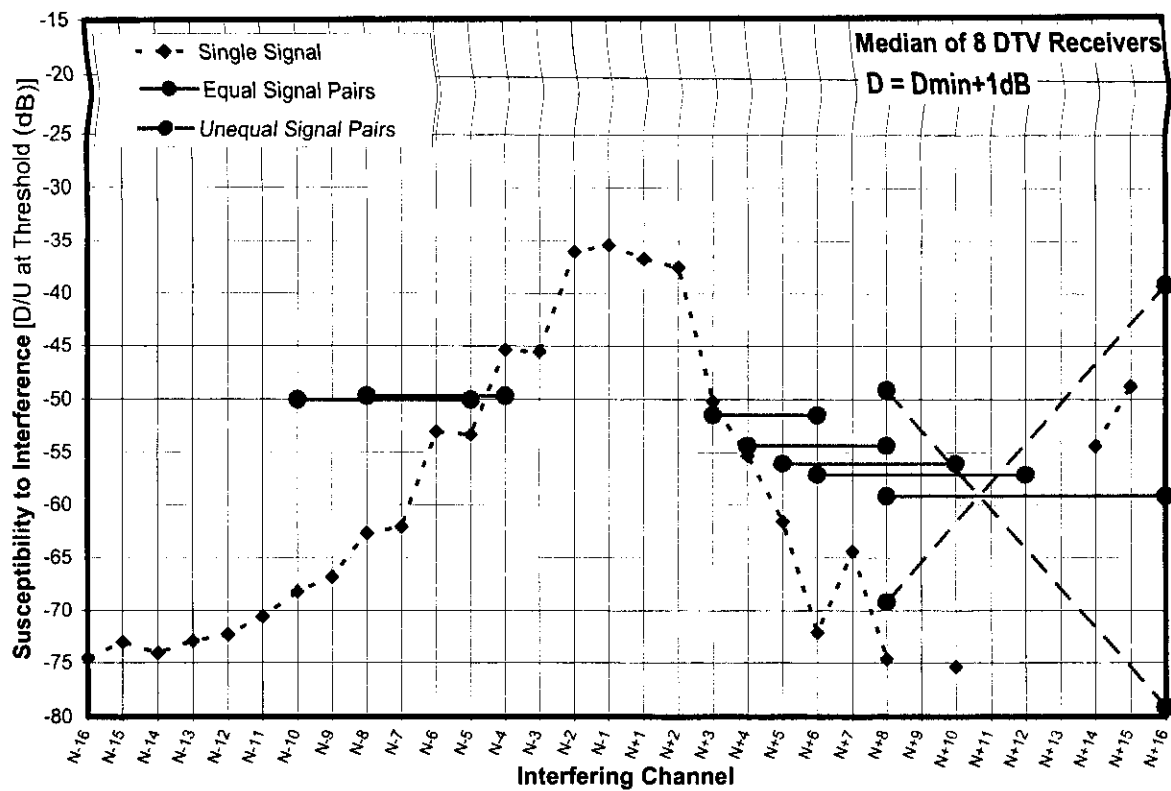


Figure 15-19. Median D/U of 8 Receivers at $D = D_{MIN} + 1\text{dB}$ With IM3 Signal Pairs

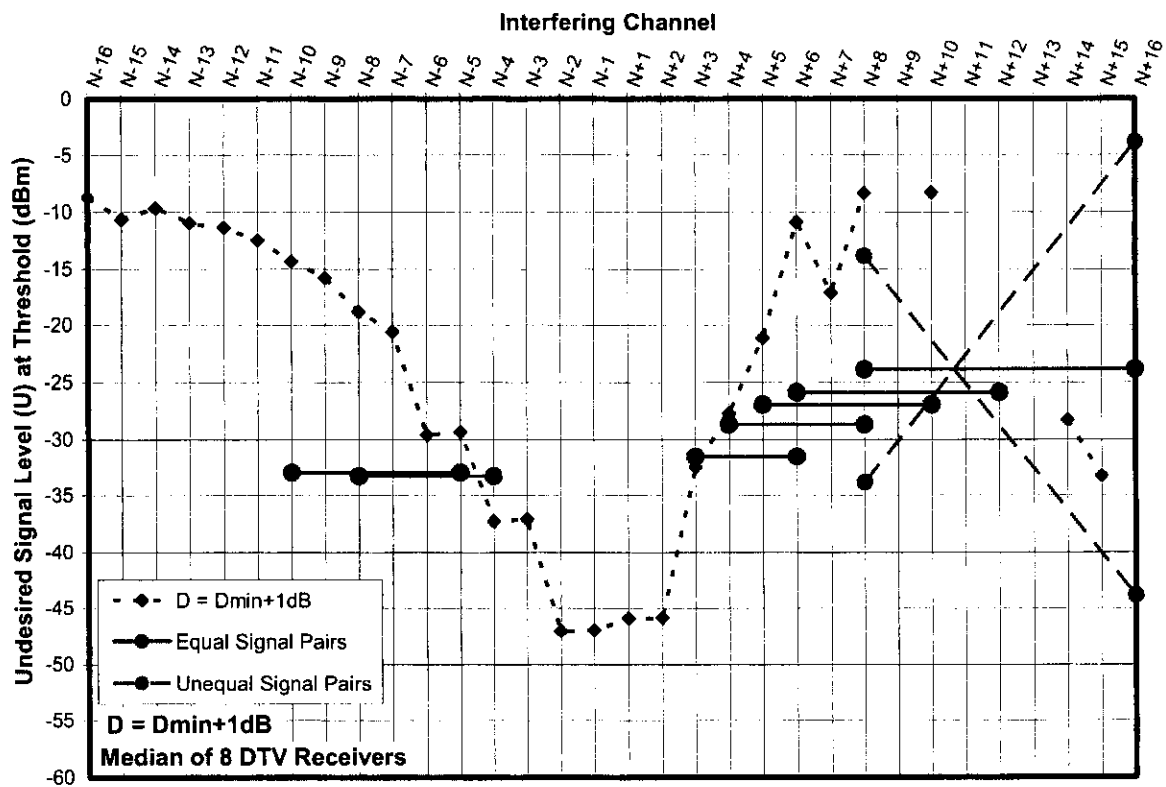


Figure 15-20. Median Threshold U of 8 Receivers at $D = D_{MIN} + 1\text{dB}$ With IM3 Signal Pairs

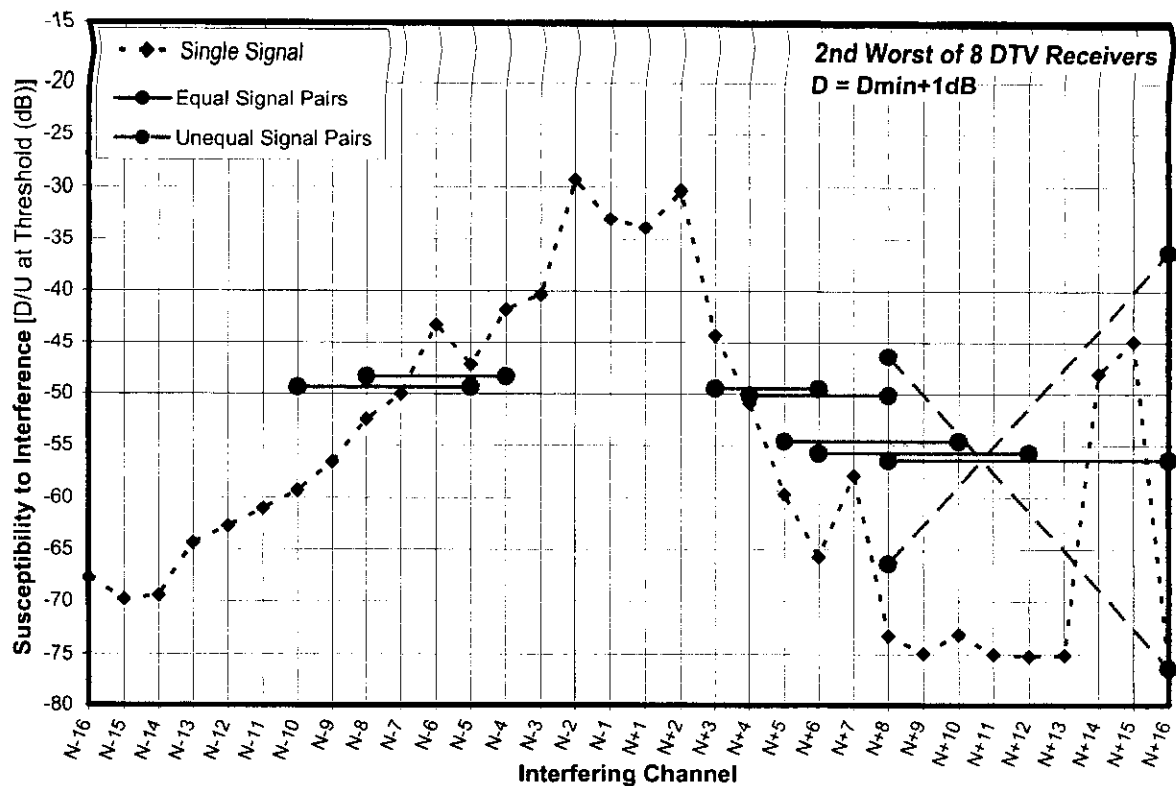


Figure 15-21. 2nd Worst D/U of 8 Receivers at $D = D_{MIN} + 1\text{dB}$ With IM3 Signal Pairs

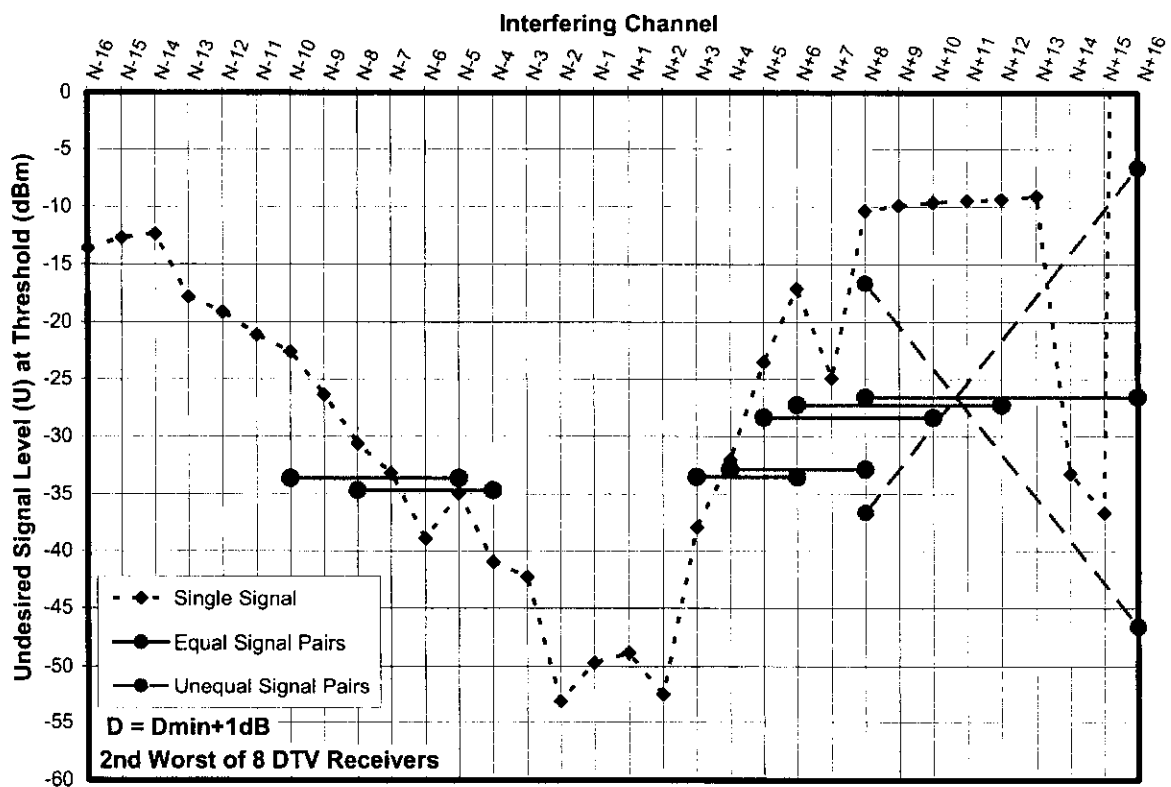


Figure 15-22. 2nd Worst Threshold U of 8 Receivers at $D = D_{MIN} + 1\text{dB}$ With IM3 Signal Pairs

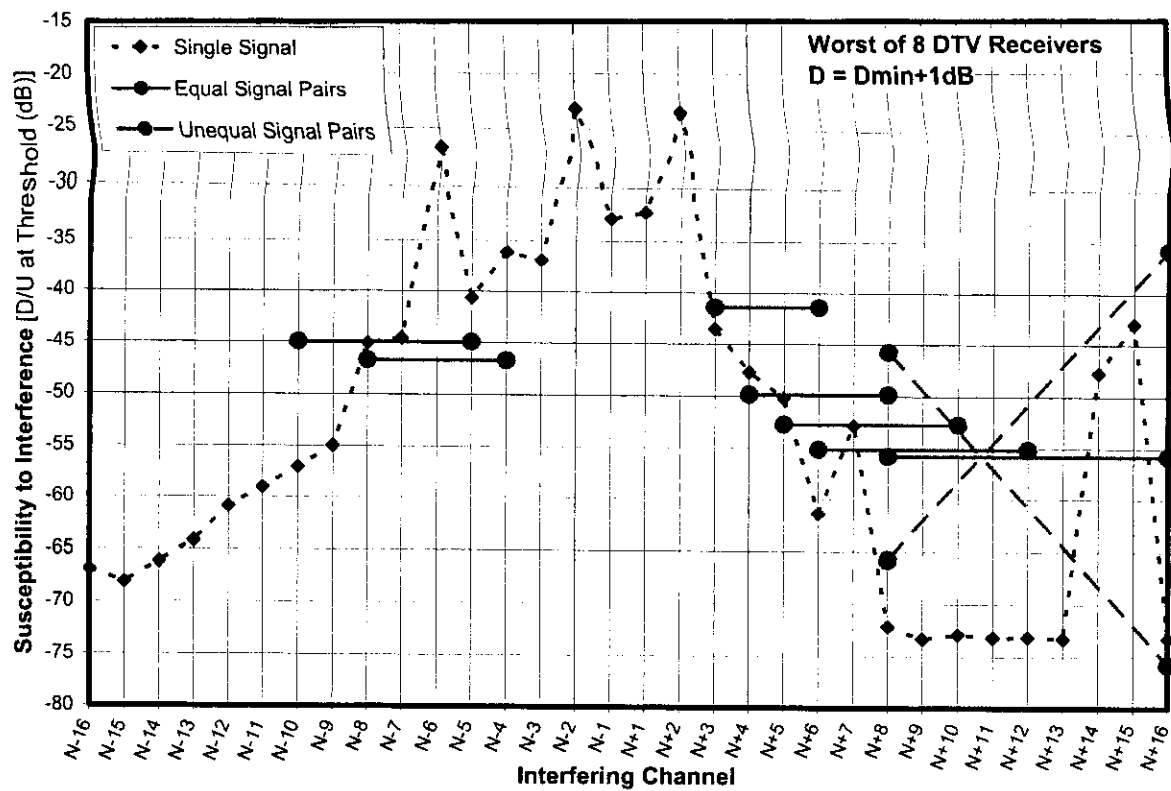


Figure 15-23. Worst D/U of 8 Receivers at $D = D_{MIN} + 1\text{dB}$ With IM3 Signal Pairs

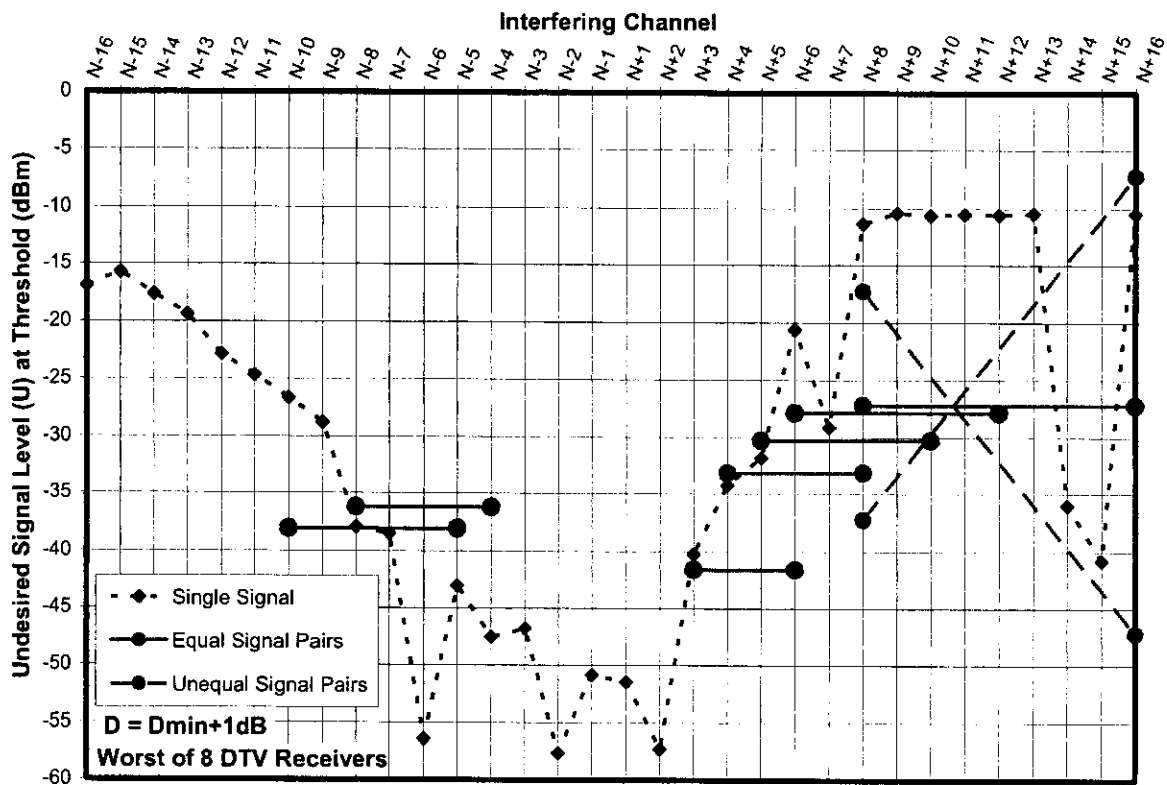


Figure 15-24. Worst Threshold U of 8 Receivers at $D = D_{MIN} + 1\text{dB}$ With IM3 Signal Pairs

APPENDIX A

TABULATED REJECTION PERFORMANCE RESULTS

This appendix includes tabulations of statistical data from the interference rejection performance measurements of eight DTV receivers on tuned to channel 30. The data are presented as D/U ratios and as threshold levels of the undesired signal U in separate major sections of this appendix.

Within each major section, a separate table is provided for rejection performance data at each of five desired signal levels:

- $D_{\text{MIN}} + 1$ dB
- $D_{\text{MIN}} + 3$ dB
- -68 dBm
- -53 dBm
- -28 dBm

The rejection performance results for the four higher levels were obtained by direct measurement. For that data, ">" or "<" symbols appear when the statistical parameter shown depends on a value that was at the measurement limit of the test setup. For example, if the "Best U" value is listed as >-6.6 dBm, that means that a valid measurement of rejection performance of the best performing receiver was not obtained due to measurement system limitations. Specifically, at that channel offset, the maximum undesired signal power that the test setup was capable of supplying to the DTV input was -6.6 dBm and the TV picture was still flawless at that level; thus we know only that the threshold undesired signal power of the best receiver was greater than -6.6 dBm. If only the best receiver measurement was so limited, values will be listed for the median, 2nd worst, and worst performance, but not for the mean or standard deviation, because those values can be computed only if all of the measurement values were valid.

The rejection results for $D_{\text{MIN}} + 1$ dB were extrapolated from measurements at $D = -68$ dBm and $D = D_{\text{MIN}} + 3$ dB, but only if valid measurements were available at both of those levels. Otherwise the corresponding cell in the table is left blank.

In the case of the measurements at $D = D_{\text{MIN}} + 3$ dB or extrapolations for $D = D_{\text{MIN}} + 3$ dB, the desired signal level was different for each receiver, based on separately measured D_{MIN} values for the receivers. Table A-1 shows statistics for the D_{MIN} values.

Table A-1. Statistics of D_{MIN} for 8 Receivers on Channel 30

	D_{MIN}	$D_{\text{MIN}}+3\text{dB}$
Minimum (dBm)	-86.2	-83.2
Median (dBm)	-84.0	-81.0
Mean (dBm)	-83.9	-80.9
Maximum (dBm)	-81.8	-78.8
Standard Deviation (dB)	1.3	1.3

THRESHOLD D/U STATISTICS FOR 8 FIFTH-GENERATION DTV RECEIVERS

Desired Signal = DMIN + 1 dB (Extrapolated from Measurements at DMIN + 3 dB)

Table A-2. D/U Statistics for 8 Receivers at $D = D_{MIN} + 1$ dB on Channel 30

Undesired Channel	Best D/U (dB)	Median D/U (dB)	Mean D/U (dB)	2nd Worst D/U (dB)	Worst D/U (dB)	Standard Deviation (dB)
N-16						
N-15						
N-14						
N-13		-73.0		-64.4	-64.2	
N-12		-72.3		-62.7	-60.9	
N-11		-70.6		-61.0	-59.0	
N-10		-68.2		-59.3	-57.0	
N-9		-66.8		-56.5	-55.0	
N-8	-72.6	-62.7	-60.3	-52.5	-45.1	8.9
N-7	-71.7	-62.1	-58.7	-50.0	-44.6	8.8
N-6	-72.9	-53.0	-51.6	-43.2	-26.6	13.9
N-5	-71.0	-53.3	-54.0	-47.2	-40.6	8.9
N-4	-65.6	-45.4	-47.9	-41.8	-36.2	9.5
N-3	-57.5	-45.5	-46.5	-40.4	-36.9	7.1
N-2	-49.1	-36.0	-36.5	-29.3	-23.2	8.4
N-1	-38.2	-35.4	-35.4	-33.0	-32.8	2.0
N+1	-38.9	-36.7	-36.2	-33.9	-32.2	2.3
N+2	-50.7	-37.5	-37.8	-30.3	-23.5	9.2
N+3	-61.9	-50.2	-50.6	-44.3	-43.5	5.8
N+4	-69.8	-55.3	-56.1	-50.9	-47.7	6.7
N+5	-67.3	-61.6	-61.0	-59.6	-50.2	5.0
N+6						
N+7	-72.1	-64.4	-64.0	-57.8	-52.8	7.1
N+8						
N+9						
N+10						
N+11						
N+12						
N+13						
N+14		-54.4		-48.1	-47.7	
N+15		-48.8		-44.9	-42.9	
N+16						

Desired Signal = $D_{MIN} + 3$ dB

Table A-3. D/U Statistics for 8 Receivers at $D = D_{MIN} + 3$ dB on Channel 30

Undesired Channel	Best D/U (dB)	Median D/U (dB)	Mean D/U (dB)	2nd Worst D/U (dB)	Worst D/U (dB)	Standard Deviation (dB)
N-16	< -76.0	-73.2	< -72.3	-67.8	-67.8	> 3.4
N-15	< -76.0	-71.4	< -72.1	-69.2	-69.0	> 2.8
N-14	< -75.3	-72.7	< -71.8	-67.6	-67.1	> 3.4
N-13	< -74.8	-72.9	< -71.4	-66.7	-65.3	> 3.9
N-12	< -74.8	-72.3	< -70.7	-65.2	-63.5	> 4.5
N-11	< -74.6	-70.5	< -68.9	-63.5	-61.6	> 4.8
N-10	< -74.7	-68.7	< -67.8	-61.8	-59.6	> 5.0
N-9	< -74.1	-67.2	< -65.3	-59.1	-57.5	> 5.9
N-8	-72.5	-64.1	-61.8	-55.1	-47.7	7.9
N-7	-71.7	-63.0	-60.2	-52.6	-47.1	7.9
N-6	-72.9	-55.5	-53.5	-45.7	-29.2	13.1
N-5	-71.0	-55.9	-56.0	-49.7	-43.2	8.0
N-4	-66.6	-47.9	-50.0	-44.3	-38.8	8.8
N-3	-60.1	-48.1	-49.1	-42.9	-39.5	7.1
N-2	-51.7	-38.5	-39.1	-31.9	-25.7	8.4
N-1	-40.7	-38.0	-38.0	-35.6	-35.3	2.0
N+1	-41.5	-39.3	-38.7	-36.4	-34.7	2.3
N+2	-51.5	-40.1	-40.1	-32.9	-26.1	8.9
N+3	-62.8	-52.8	-52.6	-46.8	-46.0	5.5
N+4	-69.6	-57.1	-57.6	-53.5	-47.6	6.4
N+5	-67.2	-63.2	-62.0	-61.8	-50.1	5.1
N+6	-73.7	-72.1	-70.0	-66.7	-61.3	4.2
N+7	-72.0	-64.4	-63.9	-57.8	-52.7	7.1
N+8	< -77.1	< -74.6	< -74.5	-73.2	-72.1	> 1.5
N+9	< -78.4	< -75.2	< -75.5	< -74.8	-73.3	> 1.5
N+10	< -77.9	< -74.7	< -75.0	-73.1	-72.8	> 1.9
N+11	< -78.3	< -75.8	< -75.8	< -75.0	-73.2	> 1.5
N+12	< -79.3	< -75.8	< -76.3	< -75.1	-73.1	> 2.0
N+13	< -79.1	< -76.0	< -76.4	< -75.0	-73.2	> 1.9
N+14	< -78.8	-58.2	< -61.5	-51.9	-51.6	> 9.9
N+15	< -78.3	-52.6	< -56.5	-48.7	-46.8	> 10.2
N+16	< -77.7	< -75.7	< -75.8	< -74.9	-73.2	> 1.4

Desired Signal = -68 dBm

Table A-4. D/U Statistics for 8 Receivers at D = -68 dBm on Channel 30

Undesired Channel	Best D/U (dB)	Median D/U (dB)	Mean D/U (dB)	2nd Worst D/U (dB)	Worst D/U (dB)	Standard Deviation (dB)	ATSC Performance Guideline (dB)
N-16	< -66.9	-64.2	< -63.9	-62.2	-59.2	> 2.7	
N-15	< -67.0	-64.1	< -64.0	-61.8	-59.7	> 2.7	-50.0
N-14	< -67.2	-64.1	< -63.8	-61.6	-59.3	> 2.8	-50.0
N-13	-67.0	-64.1	-63.6	-61.4	-58.8	2.8	-57.0
N-12	-66.1	-62.7	-63.0	-61.3	-58.3	2.7	-57.0
N-11	-65.9	-62.0	-62.1	-60.8	-56.7	2.8	-57.0
N-10	-66.0	-63.5	-62.4	-59.6	-57.1	3.0	-57.0
N-9	-65.0	-60.9	-60.9	-58.1	-56.0	3.1	-57.0
N-8	-64.2	-58.0	-58.3	-55.0	-50.7	4.5	-57.0
N-7	-64.2	-58.2	-57.2	-53.5	-48.4	5.1	-57.0
N-6	-62.5	-52.9	-52.0	-48.3	-31.8	9.7	-57.0
N-5	-62.6	-55.5	-54.3	-49.7	-44.5	5.7	-56.0
N-4	-61.9	-47.4	-49.3	-45.8	-40.7	6.3	-52.0
N-3	-59.8	-49.6	-50.1	-44.3	-41.9	6.2	-48.0
N-2	-49.7	-40.9	-40.1	-32.0	-28.1	7.4	-44.0
N-1	-40.1	-39.3	-39.1	-38.0	-37.9	0.8	-33.0
N+1	-42.1	-39.7	-39.7	-38.3	-37.9	1.4	-33.0
N+2	-48.3	-42.3	-41.1	-34.3	-29.8	6.9	-44.0
N+3	-57.0	-54.6	-51.9	-48.3	-39.8	5.8	-48.0
N+4	-60.0	-56.6	-54.9	-54.4	-41.1	5.9	-52.0
N+5	-65.4	-58.4	-56.9	-53.6	-42.6	7.1	-56.0
N+6	< -66.3	-63.1	< -61.6	-56.3	-52.9	> 4.6	-57.0
N+7	-60.3	-53.3	-51.9	-45.0	-41.6	6.8	-57.0
N+8	< -66.6	-65.0	< -64.5	-63.1	-60.9	> 2.0	-57.0
N+9	< -66.6	-65.9	< -65.2	-63.4	-62.1	> 1.6	-57.0
N+10	< -66.5	-65.0	< -65.0	-63.1	-62.9	> 1.4	-57.0
N+11	< -66.2	< -65.9	< -65.2	-63.2	-63.2	> 1.3	-57.0
N+12	< -66.0	< -65.7	< -65.0	-62.9	-62.9	> 1.3	-57.0
N+13	< -65.9	< -65.5	< -64.9	-63.3	-63.2	> 1.1	-57.0
N+14	< -65.3	-60.3	< -59.2	-52.9	-51.2	> 5.3	-50.0
N+15	< -64.8	-55.0	< -56.0	-50.1	-48.7	> 5.7	-50.0
N+16	< -64.5	< -64.2	< -64.1	-63.6	-63.4	> 0.4	
N-5/N-10	-49.8	-42.3	-43.6	-41.7	-37.2	4.2	
N-4/N-8	-46.3	-41.9	-42.4	-39.1	-38.2	3.1	
N-3/N-6	-45.2	-41.7	-40.6	-36.0	-33.0	4.1	
N-2/N-4	-51.4	-40.7	-39.3	-30.7	-29.5	7.0	
N-1/N-2	-39.2	-35.7	-34.8	-29.9	-27.3	4.1	
N+1/N+2	-39.7	-36.5	-36.1	-34.9	-29.0	3.3	
N+2/N+4	-42.3	-38.0	-37.2	-31.0	-28.9	5.1	
N+3/N+6	-51.1	-43.5	-44.0	-40.6	-33.9	5.8	
N+4/N+8	-50.8	-46.8	-46.0	-42.1	-39.6	4.2	
N+5/N+10	-52.5	-48.3	-47.9	-44.4	-42.5	3.3	

Desired Signal = -53 dBm

Table A-5. D/U Statistics for 8 Receivers at D = -53 dBm on Channel 30

Undesired Channel	Best D/U (dB)	Median D/U (dB)	Mean D/U (dB)	2nd Worst D/U (dB)	Worst D/U (dB)	Standard Deviation (dB)	ATSC Performance Guideline (dB)
N-16	< -52.2	-51.4	< -50.5	-49.2	-45.7	> 2.2	
N-15	< -52.4	< -52.0	< -50.6	-49.0	-45.1	> 2.5	-45.0
N-14	< -52.6	< -52.2	< -50.6	-48.8	-44.5	> 2.8	-45.0
N-13	< -52.8	-52.0	< -50.5	-48.8	-44.3	> 2.9	-45.0
N-12	< -52.9	-50.8	< -50.1	-48.6	-43.7	> 3.1	-45.0
N-11	< -52.9	-50.9	< -49.8	-46.8	-42.9	> 3.5	-45.0
N-10	< -52.9	-52.3	< -50.5	-48.2	-42.3	> 3.6	-45.0
N-9	< -52.7	-52.2	< -50.2	-48.1	-41.4	> 3.9	-45.0
N-8	< -52.6	-51.4	< -49.5	-47.1	-40.2	> 4.3	-45.0
N-7	< -52.3	-50.5	< -48.9	-45.7	-38.8	> 4.7	-45.0
N-6	< -52.1	-47.7	< -45.7	-36.9	-32.4	> 7.3	-45.0
N-5	< -51.9	-51.6	< -48.4	-43.8	-34.7	> 6.2	-42.0
N-4	< -51.9	-47.0	< -45.7	-39.9	-32.3	> 6.6	-40.0
N-3	< -51.8	-49.1	< -48.2	-45.2	-41.9	> 3.3	-40.0
N-2	-49.0	-41.5	-39.8	-31.8	-27.4	7.1	-40.0
N-1	-40.0	-39.0	-38.5	-37.7	-34.4	1.8	-33.0
N+1	-41.9	-39.4	-39.4	-38.3	-36.0	1.8	-33.0
N+2	-46.8	-42.2	-40.6	-34.5	-30.3	6.3	-40.0
N+3	< -50.9	-49.8	< -46.8	-48.1	-25.1	> 8.8	-40.0
N+4	< -51.0	-50.1	< -46.6	-45.1	-29.1	> 7.5	-40.0
N+5	< -51.2	-49.0	< -46.7	-44.5	-31.9	> 6.5	-42.0
N+6	< -51.4	-50.8	< -48.9	-46.3	-39.8	> 4.1	-45.0
N+7	-51.2	-38.7	-38.8	-32.6	-26.9	8.0	-45.0
N+8	< -51.7	< -51.4	< -50.9	-49.6	-48.7	> 1.1	-45.0
N+9	< -51.6	< -51.3	< -51.1	< -51.2	-49.2	> 0.8	-45.0
N+10	< -51.5	< -51.2	< -51.1	< -51.1	-49.8	> 0.5	-45.0
N+11	< -51.2	< -51.0	< -51.0	< -50.9	-50.4	> 0.3	-45.0
N+12	< -51.2	< -50.8	< -50.8	< -50.7	-50.4	> 0.3	-45.0
N+13	< -50.9	< -50.6	< -50.6	< -50.4	< -50.4	> 0.2	-45.0
N+14	< -50.5	< -50.1	< -50.2	< -50.0	-50.0	> 0.2	-45.0
N+15	< -50.0	< -49.7	< -49.5	< -49.6	-47.6	> 0.8	-45.0
N+16	< -49.5	< -49.3	< -49.3	< -49.2	< -49.2	> 0.1	
N-5/N-10	-39.0	-33.6	-34.3	-32.2	-30.6	2.8	
N-4/N-8	-38.4	-34.6	-34.2	-32.5	-28.2	3.1	
N-3/N-6	-43.6	-37.4	-36.4	-32.5	-25.4	5.8	
N-2/N-4	-41.9	-38.2	-36.4	-28.6	-28.6	5.2	
N-1/N-2	-39.0	-36.0	-34.4	-27.4	-26.3	4.9	
N+1/N+2	-38.7	-35.4	-35.2	-33.3	-30.1	2.6	
N+2/N+4	-38.9	-35.1	-33.4	-31.4	-20.8	5.7	
N+3/N+6	-41.6	-34.1	-34.4	-29.9	-22.9	6.1	
N+4/N+8	-41.2	-35.8	-36.0	-33.6	-28.4	4.2	
N+5/N+10	-41.6	-38.2	-37.7	-34.3	-32.2	3.1	

Desired Signal = -28 dBm

Table A-6. D/U Statistics for 8 Receivers at D = -28 dBm on Channel 30

Undesired Channel	Best D/U (dB)	Median D/U (dB)	Mean D/U (dB)	2nd Worst D/U (dB)	Worst D/U (dB)	Standard Deviation (dB)	ATSC Performance Guideline (dB)
N-16	< -27.3	< -27.2	< -27.1	< -26.9	< -26.8	> 0.2	
N-15	< -27.4	< -27.3	< -27.2	< -27.0	< -26.9	> 0.2	-20.0
N-14	< -27.6	< -27.5	< -27.4	< -27.2	< -27.1	> 0.2	-20.0
N-13	< -27.8	< -27.7	< -27.6	< -27.3	< -27.3	> 0.2	-20.0
N-12	< -27.9	< -27.8	< -27.7	< -27.5	< -27.4	> 0.2	-20.0
N-11	< -28.0	< -27.8	< -27.7	< -27.5	< -27.4	> 0.2	-20.0
N-10	< -27.9	< -27.8	< -27.7	< -27.5	< -27.4	> 0.2	-20.0
N-9	< -27.8	< -27.7	< -27.6	< -27.3	< -27.3	> 0.2	-20.0
N-8	< -27.6	< -27.5	< -27.4	< -27.2	< -27.1	> 0.2	-20.0
N-7	< -27.4	< -27.3	< -27.2	< -27.1	< -27.0	> 0.1	-20.0
N-6	< -27.2	< -27.1	< -27.0	< -26.9	< -26.7	> 0.2	-20.0
N-5	< -27.0	< -26.9	< -26.9	< -26.9	< -26.7	> 0.1	-20.0
N-4	< -26.9	< -26.9	< -26.9	< -26.8	< -26.7	> 0.1	-20.0
N-3	< -26.9	< -26.8	< -26.8	< -26.7	< -26.6	> 0.1	-20.0
N-2	< -26.6	< -26.5	< -26.5	< -26.5	< -26.4	> 0.1	-20.0
N-1	< -20.9	< -20.8	< -20.8	< -20.7	-20.7	> 0.1	-20.0
N+1	< -20.3	< -20.2	< -20.2	< -20.2	-19.8	> 0.1	-20.0
N+2	< -26.2	< -26.0	< -26.0	< -26.0	< -26.0	> 0.1	-20.0
N+3	< -26.0	< -25.8	< -25.8	< -25.8	-25.3	> 0.2	-20.0
N+4	< -26.0	< -25.8	< -25.8	< -25.8	< -25.7	> 0.1	-20.0
N+5	< -26.2	< -26.0	< -26.0	< -26.0	< -25.9	> 0.1	-20.0
N+6	< -26.5	< -26.3	< -26.3	< -26.2	< -26.1	> 0.1	-20.0
N+7	< -26.6	< -26.4	< -25.3	-23.9	-20.0	> 2.3	-20.0
N+8	< -26.7	< -26.4	< -26.4	< -26.3	< -26.2	> 0.1	-20.0
N+9	< -26.6	< -26.3	< -26.3	< -26.2	< -26.1	> 0.2	-20.0
N+10	< -26.5	< -26.2	< -26.2	< -26.1	< -26.0	> 0.2	-20.0
N+11	< -26.3	< -26.0	< -26.0	< -25.9	< -25.8	> 0.2	-20.0
N+12	< -26.1	< -25.8	< -25.8	< -25.7	< -25.6	> 0.2	-20.0
N+13	< -25.9	< -25.6	< -25.6	< -25.4	< -25.4	> 0.2	-20.0
N+14	< -25.5	< -25.2	< -25.2	< -25.1	< -25.0	> 0.2	-20.0
N+15	< -25.1	< -24.8	< -24.8	< -24.7	< -24.6	> 0.2	-20.0
N+16	< -24.5	< -24.3	< -24.3	< -24.2	< -24.1	> 0.2	
N-5/N-10	NA	NA	NA	NA	NA	NA	
N-4/N-8	NA	NA	NA	NA	NA	NA	
N-3/N-6	NA	NA	NA	NA	NA	NA	
N-2/N-4	NA	NA	NA	NA	NA	NA	
N-1/N-2	< -20.9	< -20.8	< -20.3	-19.3	-18.1	> 1.0	
N+1/N+2	< -20.3	< -20.2	< -19.7	-20.1	-16.4	> 1.4	
N+2/N+4	NA	NA	NA	NA	NA	NA	
N+3/N+6	NA	NA	NA	NA	NA	NA	
N+4/N+8	NA	NA	NA	NA	NA	NA	
N+5/N+10	NA	NA	NA	NA	NA	NA	

THRESHOLD U STATISTICS FOR 8 FIFTH-GENERATION DTV RECEIVERS

Desired Signal = $D_{MIN} + 1$ dB (Extrapolated from Measurements at $D_{MIN} + 3$ dB)

Table A-7. Threshold U Statistics for 8 Receivers at $D = D_{MIN} + 1$ dB on Channel 30

Undesired Channel	Best U (dBm)	Median U (dBm)	Mean U (dBm)	2nd Worst U (dBm)	Worst U (dBm)	Standard Deviation (dB)
N-16						
N-15						
N-14						
N-13		-11.0		-18.8	-19.3	
N-12		-11.4		-20.3	-22.8	
N-11		-12.5		-22.0	-24.7	
N-10		-14.4		-23.7	-26.7	
N-9		-15.8		-26.5	-28.8	
N-8	-12.7	-18.8	-22.5	-31.2	-37.9	8.8
N-7	-13.5	-20.6	-24.2	-33.7	-38.5	8.8
N-6	-12.4	-29.6	-31.3	-39.2	-56.4	13.5
N-5	-14.3	-29.4	-28.9	-35.8	-43.1	8.6
N-4	-19.6	-37.3	-34.9	-41.3	-47.5	9.1
N-3	-26.7	-37.1	-36.4	-42.6	-46.8	7.1
N-2	-36.2	-47.0	-46.4	-53.7	-57.6	7.7
N-1	-44.8	-47.0	-47.4	-49.9	-50.9	2.2
N+1	-43.2	-46.0	-46.6	-49.1	-51.5	2.7
N+2	-34.6	-45.9	-45.1	-52.7	-57.3	8.6
N+3	-23.3	-32.5	-32.3	-38.8	-40.2	5.5
N+4	-15.5	-27.7	-26.8	-32.2	-34.3	6.3
N+5	-17.2	-21.1	-21.9	-23.5	-31.8	4.6
N+6						
N+7	-12.4	-17.1	-18.9	-25.3	-29.2	6.4
N+8						
N+9						
N+10						
N+11						
N+12						
N+13						
N+14			28.3	33.9	36.0	
N+15			33.3	37.1	40.8	
N+16						

Desired Signal = $D_{\text{MIN}} + 3 \text{ dB}$

Table A-8. Threshold U Statistics for 8 Receivers at $D = D_{\text{MIN}} + 3 \text{ dB}$ on Channel 30

Undesired Channel	Best U (dBm)	Median U (dBm)	Mean U (dBm)	2nd Worst U (dBm)	Worst U (dBm)	Standard Deviation (dB)
N-16	> -4.2	-8.2	> -8.6	-12.3	-13.9	> 3.5
N-15	> -4.2	-9.7	> -8.8	-11.7	-12.8	> 3.2
N-14	> -4.2	-8.6	> -9.1	-13.3	-14.7	> 3.7
N-13	> -4.6	-9.1	> -9.5	-14.2	-16.4	> 4.2
N-12	> -4.3	-9.4	> -10.2	-15.7	-18.3	> 4.8
N-11	> -5.9	-10.5	> -12.0	-17.4	-20.1	> 5.0
N-10	-7.1	-11.9	> -13.1	-19.2	-22.1	> 5.2
N-9	-9.2	-13.4	> -15.6	-21.9	-24.2	> 6.0
N-8	-10.8	-15.3	-19.1	-26.7	-33.4	7.8
N-7	-11.6	-16.8	-20.7	-29.1	-33.9	7.8
N-6	-10.4	-25.0	-27.4	-34.6	-51.8	12.7
N-5	-12.3	-24.8	-25.0	-31.3	-38.5	7.8
N-4	-16.7	-32.7	-30.9	-36.7	-43.0	8.3
N-3	-22.1	-32.5	-31.8	-38.1	-42.2	7.1
N-2	-31.6	-42.5	-41.8	-49.1	-53.1	7.7
N-1	-40.2	-42.4	-42.8	-45.4	-46.3	2.2
N+1	-38.6	-41.4	-42.1	-44.5	-46.9	2.7
N+2	-31.6	-41.3	-40.8	-48.1	-52.7	8.4
N+3	-20.4	-28.3	-28.3	-34.3	-35.7	5.3
N+4	-13.5	-23.5	-23.3	-27.6	-32.3	5.9
N+5	-15.2	-17.8	-18.9	-19.0	-29.9	4.6
N+6	> -6.7	-8.9	-10.9	-14.4	-18.6	4.3
N+7	-10.5	-15.2	-17.0	-23.4	-27.2	6.4
N+8	> -3.2	> -6.4	> -6.4	-8.5	-9.4	> 2.3
N+9	> -1.8	> -5.3	> -5.4	-8.4	-8.4	> 2.4
N+10	> -2.9	> -6.4	> -5.9	-7.8	-8.7	> 2.1
N+11	> -1.9	> -5.4	> -5.1	-7.8	-8.5	> 2.5
N+12	> -1.8	> -4.3	> -4.6	-7.7	-8.6	> 2.8
N+13	> -2.0	> -4.1	> -4.5	-7.4	-8.5	> 2.7
N+14	> -2.3	-22.4	> -19.4	-28.1	-30.2	> 9.5
N+15	> -2.8	-27.4	> -24.3	-31.3	-34.9	> 9.9
N+16	> -3.3	> -4.6	> -5.1	-7.1	-8.5	> 2.0